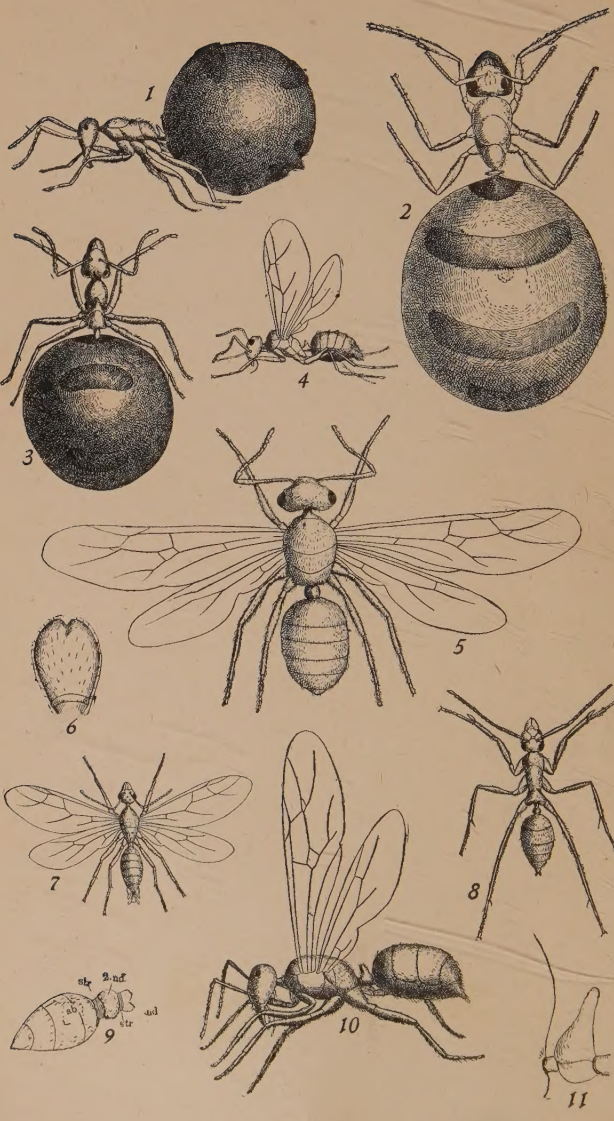
ANT COMMUNITIES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HONEY-BEARING ANTS

Fig. 1. Side view of honey-bearer × 2 (honey-ant, Garden of the Gods).

Fig. 2. Dorsal view of honey-bearer of *Camponotus inflatus*. (After Lord Avebury.)

Fig. 3. Dorsal view of Fig. 1.

Figs. 4 and 7. Views of males of *Hortideorum*.

Figs. 5 and 10. Winged female, or virgin queen, of *Hortideorum*.

Figs. 6 and 11. Node, or scale, of the petiole of queen of honey-ant.

Fig. 8. Worker-minor of *M. Hortideorum* × 4. The workers major and minim, or dwarf, are similar in form.

Fig. 9. To show the striæ (*str.*), supposed stridulating organs of *Myrmica ruginodis*.

Fig. 10. Winged female, or virgin queen, of *Myrmica ruginodis*.

Fig. 11. Node, or scale, of the petiole of No. 10.

For detailed description, see page 109 and following pages.

ANT COMMUNITIES

AND HOW THEY ARE GOVERNED

A STUDY IN NATURAL CIVICS

BY

HENRY CHRISTOPHER MCCOOK

AUTHOR OF
"NATURE'S CRAFTSMEN"
"TENANTS OF AN OLD FARM"
ETC. ETC.

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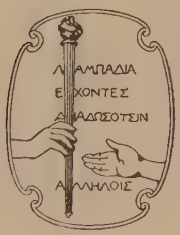
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TO

MY BROTHER

GENERAL ANSON GEORGE McCOOK

COMPANION, COMRADE, FRIEND, ALWAYS LOVING AND
WELL-BELOVED. IN EVERY OFFICIAL TRUST
BRAVE, PATRIOTIC, COMPETENT, AND
INCORRUPTIBLE. IN EVERY RELATION
OF LIFE JUST, HONORABLE
LOYAL, AND KIND

A FULL-ORBED MAN

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PREFACE

THREE years ago, in his *Nature's Craftsmen*, the author presented a series of original studies of the life history of sundry insects. Half of the book was given over to one of his specialties—the ants. The remainder embraced accounts of another specialty, the spiders, and of certain insects that had received particular attention as a sort of by-product of his special studies. The author's purpose therein was to give his readers a veritable natural history of the subjects treated of, in popular form, and clothed in at least some measure of the simple graces of good literary style.

The present volume, while aiming to preserve the above features, differs from *Nature's Craftsmen*, in that it is limited to the natural history of ants. Moreover, it considers mainly those phases of their life that are developed around their behavior as social animals. It is here that appear most clearly and fully the habits which have drawn to these insects from the earliest ages the attention of man, and have won for them a high reputation for wisdom.

From this has arisen a secondary feature of the book —*viz.*, the indication of parallels, more or less distinct, between the communal actions of ants considered simply as natural history, and the communal actions of man, considered, as all human beings are bound to

consider them, in their relations to the highest welfare of the race.

The association of separate groups of individuals to accomplish the primary aims of physical life is almost sure to develop resemblances in methods. What are those aims? Among ants, as the following pages will show, they are the establishment of a home; procurement of a livelihood; protection from enemies; preservation and nurture of the young and other communal dependents; perpetuation of the species, and the propagation of the commune.

Wherein do these differ from the common necessities and aims of men in their social aggregations? They are practically the same. The Great Hand of Sovereign Nature that has laid upon her children these common aims has so guided them in the achieving thereof, that, amid the endless variations which issue from an Infinite Fountain of Design and Force, one traces resemblances in methods that suggest their common origin. In our studies, these likenesses, as well as unlikenesses and contrasts, will be interesting to note.

In many of the higher and complex duties of human communities it is impossible that insects should be models for men, in whom there is an element that separates from all other creatures by an impassable gulf. But in the great physical functions of a commune, which are a bond of sympathy between us, we may have something to learn from the ants, who manifestly have kept and still keep to the primitive ways of nature more closely than we. Sometimes these lessons have been pointed out, sometimes simply suggested, sometimes left for the reader to discern. But whether the one or the other, the author ventures to hope that they may

stimulate thought and discussion, or at least interest, but in no wise divert from his main purpose: to increase knowledge of the natural history of creaturelings that have contributed so much to his own enjoyment of life.

It has been more than thirty-two years—almost a full generation of men—since the author published in the *Transactions of the American Entomological Society* (Philadelphia) his first observations of American ants. Since then he has given to the world in books, in publications of scientific societies, and in magazine articles, his studies of various species, chiefly devoting himself to their habits rather than to their systematic classification. In this volume, *Ant Communities*, taken together with the first part of *Nature's Craftsmen*, he presents a substantial summary of these prolonged observations. And he has brought them down to date by associating therewith the latest observations of some of the leading naturalists of the scientific world.

"Brookcamp," Devon, Pennsylvania.

ANT COMMUNITIES

ANT COMMUNITIES

CHAPTER I

FRATERNAL CONFEDERACIES AND COMMUNAL RIGHTEOUSNESS AMONG SOCIAL ANTS

ORGANIZED society, whether among insects or men, implies some form of government; and that implies citizenship. And fidelity to the just and natural service of citizens is communal righteousness. May we apply such a term to insects? And if so, what is the character of such a quality; or, if one may venture so to put it, what is the quality of such a character? And is it in any measure comparable with communal righteousness as the phrase goes among men? The inquiry will here be limited to ants; but the study requires the statement of some preliminary facts, so that readers may have a true conception of the field which our thoughts are to explore.

Some insects are "solitary"; they live alone. Others are "social"; they live in communities. There is such a striking contrast between the manners of the two groups that one wonders how the distinction arose. True, at the beginning of life most insects are massed, since their mothers lay their eggs in compact clusters. But if one start with the theory that this may have left

in the germ of being a tendency which, under favorable conditions, might be transferred to the adult, he is met by certain facts that may confound his reasoning.

For example, the eggs of ants and bees are dropped separately, yet they produce insects of the strongest social habits. The moth of the tent caterpillar oviposits in clusters, and her progeny keep together in the larval state. The eggs of the garden orbweaver, like those of most spiders, are laid in carefully sheltered masses, and the young are partly reared together in the silken tent which the mother overspins. Moreover, they start independent life in a self-woven silken compound. The lycosid, a ground-spider, drags her round cocoon behind her until the eggs are hatched, and then bears the younglings about clustered upon her back. Yet soon the centrifugal factor in vital force drives the young of moth, orbweaver, and lycosid asunder, and thereafter their life is solitary.

With social insects the tendency is reversed. Beginning life solitary, as in the case of the maternal founder of an ant's nest, the individual becomes a family, and the family a community, and this may develop into a vast commonwealth containing many thousands or even millions of individuals. When the circle of life is complete, the vital centripetal force which binds these communities together is relaxed, in a movement of impassioned communal fervor, to allow the outgoing of the winged males and females, as with ants; or the swarming of a new community, as with bees. This is the "commencement" time in the insect calendar, when a matured sliver of the community is struck off and pushed into independent life.

Among ants these communities vary in population

from a few score to many thousands. There are villages, towns, cities—each, for the most part, independent of all others, and each complete within itself, a separate tribe, a sovereign state. That the orderly and successful conduct of such communities must spring, consciously or unconsciously, from some system, is self evident. What is that system? What are its laws, its customs, its methods of administration? Is an ant-hill a monarchy, a republic, a democracy, a socialistic commune? How does its government compare—if in any wise comparable—with the civil governments of men? And what lessons in civics can we learn therefrom?

Surely, an interesting inquiry here opens up; for, whatever the result, it must give us a glimpse of nature pure and simple. To this the author's purpose is mainly directed; but, as a by-product of his studies, he confesses a keen interest in those reflections that traverse the field of human civics, and which inevitably arise as one pursues the history of life in ant communes.

In many parts of the Alleghany Mountains, and in middle and eastern Pennsylvania, in New Jersey, in the White Mountains and elsewhere, are distributed the large conical nests of the mound-making ants of the Alleghanies, *Formica exsectoïdes* (Fig. 12). These vary in size from newly begun colonies a few inches high to mature hills, measuring thirty-seven feet in circumference at the base, though rarely more than three feet high. They occur in groups; and in one site near Hollidaysburg, Pennsylvania, within a space of fifty acres, the writer counted seventeen hundred well-developed mounds. At two other localities in these mountains similar groups were observed even more thickly placed. At "Pine Hill" about thirty acres were occupied, of which

five were found to contain two hundred and ninety-three mounds, an average of fifty-nine to the acre, or eighteen hundred for the whole section. At "Warrior's Mark"

Fig. 12—A GROUP OF MOUND-MAKING ANTS' NESTS
(*Formica exsectoïdes*)

another large settlement of nearly two hundred hills was visited. Experiments made in the Hollidaysburg group proved that all therein formed substantially one community, in complete fellowship, although the in-

dividual mounds appeared to be conducted independently. The following will illustrate these experiments. [McC. 2, p. 282.][1]

A small oak-branch covered with aphides and their attendant ants was broken from a tree and placed erect upon a mound twenty rods distant. It was thought that if anything would incite to hostility, it would be the intrusion of members of a separate community upon a congener's feeding-grounds. On the contrary, the ants being called from the hill, came out and mounted the branch with the usual excited bearing, and then mingled with its original occupants on friendly terms, and began to feed quietly from the galls and aphides. A larger branch having many more ants upon it was cut, and planted upon a mound a considerable distance beyond the first one. The insects were called out by tapping upon the surface. The usual whirl of angry sentinels and other workers followed, and then all blended with the intruded ants without a sign of hostility.

A spadeful of earth was swiftly cut from the mound, and with ants, cocoons, and broken cells, thrown into a pail, carried to a cone fifty rods distant, and cast upon the surface and around the lower gates. One could not distinguish between the citizens of the two mounds as masses of excited ants poured out and began their usual movements, but no marks of hostility appeared. After the first sharp challenges with crossed antennæ the imported ants melted away into the general community as though at home.

The only other test of this nature which need be mentioned was made with three hills (D, E, F), to

[1] *See* "Table of Authors," Appendix.

which reference will be made hereafter as the "hysterical hills," on account of the abnormal state of excitement which marked their inmates, and for which no reason was apparent. Large pieces of the mounds D and E, which were twelve feet apart, were interchanged, tossed violently from one to another. Although swarming with insects intensely agitated, there was no appearance of hostility at either mound.

I then proceeded to F, one hundred and fourteen feet distant, and called out the ants until the cone was fairly black with them. From the densest centre of life was cut out a section about six inches square and borne hurriedly to D, catching *en route* the dropping ants in a hat. The contents of shovel and hat were thrown upon the cone in the midst of its hosts of inhabitants. Even this violent invasion which, with an alien species would have been a signal for war and slaughter, was not resented. There were sharp antennal challenging and quick response, and then the newcomers melted away into the mass of their enforced hosts, as fellow-citizens "to the manner born." There was complete fraternization, which was not afterward disturbed by any breach of the peace.

The final test was an artificial nest prepared in a large glass jar within which earth, sticks, and surface litter were placed. Ants taken from a number of mounds situated in parts of the field and wood most remote from one another were put in. Cocoons from yet other cones were added. Aphides, water, and honey were then given them. This miscellaneous assemblage united with the utmost harmony in building galleries, caring for the cocoons, and defending the nest from intruded ants of separate species and from spiders. From time

to time ants and cocoons collected from widely separated hills were put in, and these were always and at once adopted. This amity and co-operation in the duties and responsibilities of good citizenship continued until the composite republic of drafted citizens was broken up.

The natural explanation of these rare conditions is this: the antennal interchanges between the various parties at once showed that all were fellow-citizens of one commonwealth, equally entitled to communal welcome and place, which were accorded at once upon the recognition of the one common nest-odor which is the badge of citizenship.

Thus it appeared (and to the writer it was then an astounding revelation) that among the myriads of creatures occupying these more than seventeen hundred mounds there was complete fraternity—if, indeed, they were not one mighty confederacy! Here was a republic which in the number of its separate states—for every mound was an independent community of ants—and in the multitude of its total population exceeded the most sanguine prophecy of the future American republic. It would be hard to conceive of anything like local or communal loyalty, an inflated devotion to "state rights," or that jealousy and conflict of interests which are apt to develop among neighboring communities, as leading on to war among the insect commonwealths which were the subjects of the above experiments.

If a city be (as it has been defined) "a place inhabited by a large, permanent, organized community," the name "Ant City," by which it is popularly known, is fitly given to this vast concourse of united emmets, or, indeed, to any one mature colony thereof. Naturally the question often occurred, How many ants are here

assembled? An exact census in such a case is impracticable, but at least a reasonable approximate is possible. Dr. August Forel, the eminent Swiss myrmecologist, has described a community of two hundred mounds of a closely related species (*Formica exsecta*) among the mountains of Switzerland, as having each a population ranging from five thousand to five hundred thousand. If one were to apply the lowest estimate (five thousand) to our American community, it would give a total population of eight and a half million living creatures! That is quite enough to justify their claim to the title of "city," but, in truth, a conservative estimate would make them many times as numerous.

In his *Die Nester der Ameisen* (Ants' Nests) [F. 4 and 5], in commenting on my observations upon this sodality of the Alleghany Mountain ants, Doctor Forel says: "These ant kingdoms have, in all probability, a population of two hundred to four hundred million inhabitants, all forming a single community, and living together in active and friendly intercourse." Think of it! A population equal to that of the whole empire of China! And this is not a wild guess of an enthusiastic visionary, but the sober calculation of the veteran chief of Europe's myrmecologists, and one of its foremost medical specialists. I have spoken of this mighty concourse of organized insects as a city; but doubtless kingdom, or empire, might be a better title, for there was throughout the settlement a marked tendency to groups of mounds of different sizes, which might represent the cities or large centres of population distributed throughout a commonwealth.

No North American ant exceeds these mound-builders in the size of the structures reared by them. But in

some tropical lands even larger mounds are found. Livingstone speaks of ant-hills in South Africa that dotted the face of the country like haycocks in a harvest-field. In the woods they were twenty feet high and forty to fifty feet in diameter! [Li. 1, p. 590.] These rival the great gothic erections of the termites. Whether the African ants show the communal unity that exists among our Alleghany mound-builders has not been determined. But such unity must obtain among the vast hordes that occupy each hill.

One who studies the economy of these communes soon notes a well-defined division of labor among the three worker castes—*viz.*, workers-major, workers-minor, and minims or dwarfs. There are sentinels or policemen, masons or builders, foragers, nurses, and courtiers or queen's body-guard. These are not so differenced as to form fixed classes which embrace always the same individuals with duties limited to one sort of service, as is the case in some other species. Apparently, all branches of service have recruits from all the castes, and these pass from one duty to another at will. On the surface (as far as human intelligence discerns) it is a "go-as-you-please" arrangement, which nevertheless is dominated by some occult principle that brings orderly results out of seeming chaos.

There appears to be no specialized warrior caste among these formicans, but there are sentinels, or policemen, whose duty it is to guard the community from hostile approach. Their internal affairs call for no domestic police. Among these millions of citizens there is not one criminal, not one degenerate! I do not recall, in all my long and varied observations, a single example of an ant whose actual offending called for the administra-

tion of civil punishment. Nor do I remember to have read of such a case in natural history. Emmet outlawry is unknown. These vast communities are self-policed. Their citizens are so perfectly self-controlled, so absolutely free from even the desire to violate law, that as against them a domestic police would be a sinecure. Do you look for the perfect social commune whose citizens are all perfect in that "righteousness which is of the law"? One may find it here.

But public enemies abound. Eternal vigilance is the price of peaceful industry and security. Here are millions for defence, though not an ant be needed to support home government. And to this end every citizen, if need be, is a soldier-policeman. Watchmen continually guard the various gates, or entrances, to the cone, most of which are ranged along its base just above the ground, but some are placed between that and the summit. These sentries lurk inside the gates, whence they issue, with every mark of intense excitement and watchfulness, if one approaches a finger or drops some object near them. Frequently they patrol the vicinity of the gates, and attack intruders with promptness and intrepidity (Fig. 13).

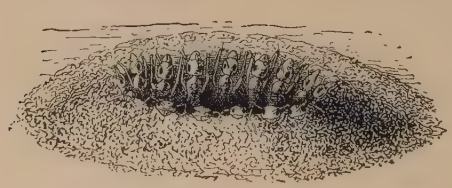


Fig. 13—WATCHMEN AROUND THE GATE OF A HONEY-ANTS' NEST

This is a prevalent manner of ants. There is but one large tubular entrance to the pound-cake-like mound of the honey-ants of the Garden of the Gods (*Myrmecocystus hortideorum*) in Colorado. Around its upper rim, with their yellow heads and quivering antennæ

just in view, one sees a ring of sentinels. At the door into the pebble-sheathed cone of the occident ant (*Pogonomyrmex occidentalis*) of the American plains, which opens into the breast of the cone, the watchmen wait, intent and vigilant. So it is elsewhere, and almost everywhere, that ants are found in large communities. It is the law of emmet as it is of human society, that

> "Some must watch, while some must sleep;
> So runs the world away!"

These watchmen do not always belong to a soldier caste. Every emmet citizen who has passed the brief callow stage of first emergence from pupahood is a policeman or soldier on occasion, and may, as far as the facts now appear, go on sentry as on any other duty. It would not be strange if, in the gradual development of such a social system, certain individuals should have shown special aptitudes for police service that kept them more or less continuously therein, and so have arisen something like a soldier class. In some species such has been the case, as with those of the genus Pheidole, and the leaf-cutting or parasol ants of Texas.

But it is not so with our mountain mound-builders. They remind one of the militia organization of our earlier frontier States—Ohio, for example, which made every adult male, not disqualified by age or otherwise, subject to military duty. Indeed, such is, in theory, the relation of all citizens of the American republic to the general government. Among our ants that duty is never dodged. There are no desertions. Lazy, cowardly, and skulking ants one does not see. With heartiest good-will the call to service is met, and a "clear call," apparently, is simply a perception of the commune's danger and need.

Then, at a touch, every citizen becomes a warrior, and the outer walls swarm with defenders.

Here one may note a remarkable trait of these ant citizens—their devoted patriotism. At the approach

Fig. 14—GROUP OF TWO MOUNDS OF F. EXSECTOÏDES AT ALGONAC, ST. CLAIR RIVER, MICHIGAN
(Photo by William S. Cooper, Detroit)

of an enemy they attack it, absolutely regardless of consequences. The personal factor has no place nor even consideration in the act. Whether the supposed hostile be great or small, beast, bird, creeping thing, or man himself, the brave little creatures fling themselves upon it with the utmost abandon.

For example, here comes to the edge of the mound a large black carpenter ant (*Camponotus pennsylvanicus*), a ferocious and formidable insect, almost twice as large as the formican and a hereditary enemy. Forth from a gate leaps a sentinel, and launches its quivering body straight against the sable giant. One snap of the Camponotid's jaws, and the assailant's brown head is

severed, and its beautiful life extinct. Another sentinel follows, and another, only to meet the same fate. But others crowd to the combat, eagerly facing and meeting wounds and death. Overwhelmed by numbers, the black warrior is at last conquered and dragged into the formicary, where its dismembered body is sucked dry and its shelly parts dumped upon the refuse-heap, or mayhap built into the growing walls, along with vegetable débris of various sorts.

This courageous and unselfish disregard of person and absolute devotion to the communal safety at the cost of life or limbs is characteristic of ant citizens; not of a few, but of all; not rarely and occasionally, but always; not under compulsion, but freely and without

Fig. 15—SINGLE MOUND OF F. EXSECTOÏDES, BRUSH MOUNTAINS, PENNSYLVANIA

reward of any sort. Not even the high stimulus of applause of comrades and of honors from their fellows urge and sustain them. Such conduct is so much a

matter of course that no one notes it as extraordinary, and a war-scarred veteran may be seen dragging its maimed limbs into action, or in some obscure corner licking its hurts and waiting for the end without nurse or comforter. It has done its duty, and accepts the result with imperturbable unconcern, as do its fellows.

Apropos of these studies of police administration of our ant commonwealth is an observation incidentally made while conducting experiments to determine the mode of recognition among ants. Starting upon the theory that it was a specific odor or emanation analogous thereto by which our mound-makers recognize one another, the matter was tested by subjecting individuals to baths of clear water, and infusions of wintergreen, cold coffee, and tea, and then returning them to their mounds. The individuals thus treated were immediately attacked by roundsmen, a dozen or more sometimes, and dragged away like culprits. These assailants were then taken with their victims, submerged, and restored to the hill with the same result. So with a third series; the assailants of the assaulted ants were in turn attacked, and invariably the same measure meted to them that they had measured to others. They had lost, for the time at least, the "mark" of their citizenship. [McC. 2, p. 281.]

In some cases the parties assailed were soon released, as though the mistake had been perceived. But for the most part there was every indication of a mortal purpose and a fatal issue. It was here that a curious trait was developed. The demeanor and conduct of the immersed and "tainted" ants were in marked contrast with their character for valor in battle and pluck generally. They were quite passive under the fierce

assault of their fellows, and succumbed with little or no effort to resist. They seemed to have the carriage of persons detected in some meanness or crime—a "hang-dog" sort of air.

Could it be that these unfortunates tacitly recognized the fact that they had become obnoxious to the communal police? And, although this had come about by no fault of their own, was their instinctive sense of obligation to submit to the "legal authority" which dominated the commune so imperative that they yielded themselves to their fate, temporary captivity or death as the case might be, without the least show of resistance? One's judgment is so apt to be biassed by his interest in and sympathy with these wise little creatures that he is inclined to distrust even his most careful observations, and fear that unconsciously he may have interpreted their behavior by the operations of his own mind. But in this case so many tests were made, all yielding like results, that the above conclusion seemed to be justified.

And why should it not be so? The higher animals are not insensible to the public sentiment of their kind, as one may see from the actions of domestic flocks and herds and of gregarious wild beasts. It is what might be looked for in social insects, though therein less noticeable by human senses; for ages of hereditary communal life must have wrought upon their sensibilities, so keen in certain quarters though defective in others, a marked response to an environment of active disapprobation.

One does not speak of this as a conscience, perhaps not even as a remote analogue thereof. But it seems to take the place of that sentiment, or experience, or inward

impulse and restraint in man, without which no communal government is long possible. What is it that imparts to our genus elements of chaos, crime, misrule, and misery so far beyond the qualities of social insects (if also so vastly above them), and which starts up in the path of history records of communal disorder that one seeks in vain among ants, hornets, and wasps? Why should a creature with a conscience ever be less steadfast and exemplary in communal righteousness than a citizen of a commune of mound-making ants?

CHAPTER II

NESTING ARCHITECTURE—HOUSING THE COMMUNE

THE housing of the commune is a duty that springs up side by side with the existence of the commune. In the typical beginning of an ant community by the single fertilized queen, the first act of the incipient foundress is to scoop out and heap around her, in earth or wood, a cell whose diameter is somewhat greater than the length of her own body. This is the rudimentary house of the commune—the primitive cave which bounds the architectural aim of most animals, and which is the starting-point with man himself (Fig. 16).

With great numbers of species, this cave will be found under a stone. A flat stone, not too large and not deeply imbedded in the ground, if lifted up in the early spring, or at any time during summer, will be found to serve as a rocky roof which overspreads the vestibule and protects certain galleries, halls, and passages into an underground formicary. The mere fact of choosing such a location for a nest is significant; for, besides the protection and defence afforded, the stone absorbs the sun's rays and serves thus as a natural furnace, contributing to the warmth of the ants and of their immature young.

Like the ancient catacombs of Rome, which served primitive Christians equally for home, for sanctuary, and for cemetery, these subsurface chambers and

galleries are arranged in irregular stories, one above another. They are simply the primitive cave in multiple, with intercommunicating passages. And they increase on the principle of any other social settlement—to meet the communal growth. Many of them reach immense proportions; most of them are comparatively small.

(By courtesy of the American Museum of Natural History)

Fig. 16—ORIGINAL CELL OF CARPENTER ANT QUEEN, AFTER WHEELER

With the great army of woodworkers the same simple type of architecture prevails, modified simply and not largely by the material from which the public buildings are wrought. The storied subdivisions especially are crowded within a narrower space and are less distinctly marked. One who carefully studies the architecture of a long-established nest of carpenter ants will find himself unconsciously tracing out in miniature pillars, arches, aisles, vaults, and domes of different orders of architecture. It takes but a slight stretch of fancy to imagine that one is gazing upon the ruins of an ancient seat of a diminutive type

of his own race, who had carved out their toy-like homes and temples in the solid wood.[1]

One of the most interesting examples of the storied type of underground architecture is that of the honey-ants of the Garden of the Gods (*Myrmecocystus hortideorum*), Colorado, the farthest north they had been observed. The approach to their nest was a small, low, pebble-covered mound with a large central gate which penetrated it vertically for a few inches, and then was diverted into various passages that followed the slope of the ridge on which the colony was planted (Fig. 17).

In one nest, chosen for complete exploration, excavation was carried forward during three days and several

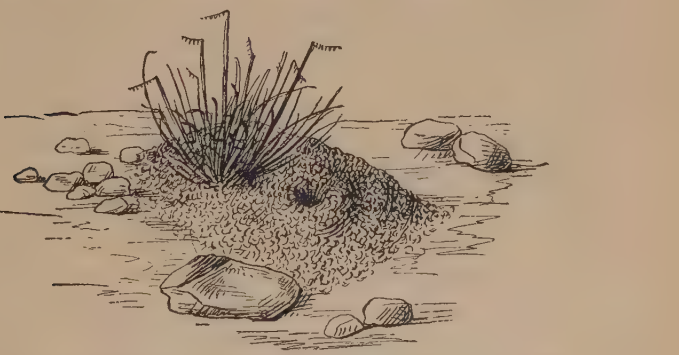


Fig. 17—EXTERIOR ARCHITECTURE OF HONEY-ANTS OF THE GARDEN OF THE GODS (*Myrmecocystus hortideorum*)

parts of days, two men working with mallet and chisel and with knife in the soft, red sandstone, or "pudding-stone," of which the ridge is composed. The entire length of the formicary was seven feet eight inches.

[1] *Nature's Craftsmen*, p. 120.

The point at which it ended was forty and a half inches below the level of the main gate and twenty-nine and a half inches beneath the level of the hillside. In all, the ants had excavated thirty-six cubic feet of rock, and this space was honeycombed with galleries and rooms. The latter varied from five to six inches long, three to four wide, and about three-fourths of an inch high. The walls and floors of these rooms were smooth, but the roofs were left in their natural roughness, thus forming a better foothold for the rotunds, or honey-bearers, who were perched upon them, clinging thereto with their claws, and closely clustered together. [McC. 4, pp. 36, 37.]

The occident ant (*Pogonomyrmex occidentalis*) is closely related to the agricultural ant in structure and habit (Fig. 18). But the typical forms vary decidedly in their exterior architecture, the occident having its commune overbuilt with a prominent cone coated with pebbles, while the typical agricultural keeps the space around its gate free from all growth. Both species, like the mound-making ants of the Alleghanies, are among those that found and maintain vast communities, and therefore have a special interest to us in our present studies. Their homes are often wrought in a tough clay that is almost as hard to excavate as the red sandstone of the Garden of the Gods, and equally taxes the resources of the workers. The arrangement of rooms into stories is here also carried out, and to a surprising extent. In one nest of the occident ant a story was found at a depth of over eight feet beneath the surface (Fig. 99).

Those who are curious in such comparisons might find grounds here for a striking parallel between the achievement of an ant three-eighths of an inch high

(long), and of a man one hundred and seventy-six times as high (five and one-half feet). [McC. 4.] Were we to reckon a proportionate rate of progress between the two on the basis of height, our man would have to

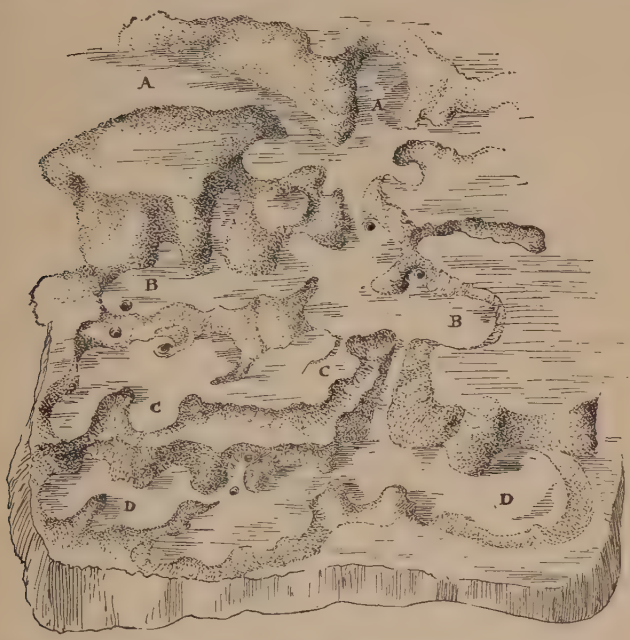


Fig. 18.—A CONNECTED SERIES OF STORE-ROOMS (A, B, C, D), OR GRANARIES AND CHAMBERS OF THE OCCIDENT ANT

be credited with a storied structure one thousand four hundred and eight feet deep. Apart from such fanciful comparisons, it is certainly well calculated to excite our wonder that such insignificant creatures can, by their united exertions, bring about results relatively so vast, unaided by mechanical contrivances.

The numerous chambers which in honey-ant structures

Fig. 19.—INTERIOR OF A STORIED COMMUNE OF THE OCCIDENT ANT OVER EIGHT FEET DEEP

are occupied by those living honey-pots, the rotunds, in the occident nests are used as store-rooms. Herein one finds various sorts of seeds put away for food. In a few cases rooms were found filled with husks and apparently sealed up, as if empty spaces had been utilized in the rush of business for "dumping-grounds," to save transporting the waste matter of the seeds to the outer gates and the kitchen-middens. Perhaps these "relief chambers" were merely a temporary makeshift, and would have been cleared out in due course had not the commune suffered a destruction as dire as that of ancient Troy or Carthage.

Such great structures as have been described here imply the work of years, and it is probable that some of them were several years old. They showed every mark of such age; in fact, the continuous life of an ant community, in such sharp contrast with that of our hornets and yellow-jackets, which do not survive October, would naturally demand permanent or continuous residences, the permanency of the community and the permanency of their dwelling going naturally hand in hand. By calculations made from the levelled floors of the mountain charcoal-burners, which had been occupied by large mounds since their abandonment, I concluded that some communities of *Formica exsectoïdes* were at least thirty years old, and I believe that they remain active for a longer period if unmolested.

Livingstone (South Africa) speaks of ant-hills which dotted the face of the country like haycocks in a harvest-field. In the woods they were seen twenty feet high and forty to fifty feet in diameter. He also notes the fact that these spots are more fertile than the rest of the land, and are the chief garden ground for maize,

pumpkins, and tobacco. This statement has a significant bearing upon the part assigned in nature to ants and other insects in making the earth habitable by agricultural man. [Li. 1, p. 590.]

The pebble roofing of the cone of the occident ant is a permanent feature (Fig. 20)—at least, of the immense number seen by me, all were covered with pebbles of the gravelly soil in which they stood. In the vicinage of the Garden of the Gods the pebbles were red sandstone. The mounds in Wyoming observed by Prof. Joseph Leidy were covered with a white stone. Mr. R. Hill saw them

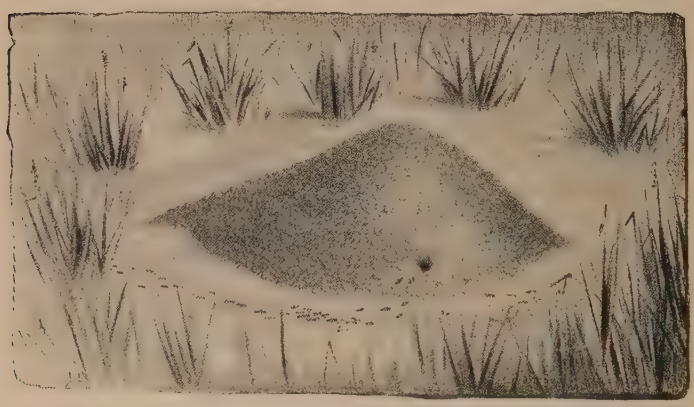


Fig. 20—PEBBLE-ROOFED COMMUNE OF THE OCCIDENT ANT

on the Sapa Creek, in northwestern Kansas, roofed with pellets of the limestone rock in which the great fossils are found, and in one or two cases even of portions of the fossils. Thus the conditions of the famous riddle of the Judæan Hercules are repeated in this far Occident, and the hymenopterous allies of the bees who nested in the skeleton of Samson's lion burrow and build a home

among the bones of extinct creatures of the geologic ages.

These roofing pebbles are not (or but sparsely) intermingled with the soil of which the interior bulk of the cone is composed, but form a stone covering, or roof, about a half inch thick, more or less. Mr. H. L. Viereck informed me that he had seen bits of cinder and coal, evidently gathered from the railroad track, for roofing. This is confirmed by the statement of Mr. G. A. Dean [D. 1, p. 169], who further says that on the old town site of Wallace, Kansas, they used bits of glass, mortar, and small fragments of rusted iron from the débris of ruined houses. Thus the roofing habit, though it may have originated from the accidental deposit of excavated pebblets, seems to have grown into a fixed purposeful instinct that prompts to gather supplementary material from any available quarter.

The pebbles are handled with ease by the worker-ants, who nip them with their outstretched mandibles and then move off, rarely stopping en route to adjust the burden or to rest. The body is lifted up, the head well elevated to prevent bumping against the surface, and the load held well to the front or somewhat beneath the body. The portage was amply observed during ordinary excavations, in opening and closing gates, and in repairing breaks caused by rains or purposely made for experiment. In the last-named work the ants would descend to the clearing at the base of the cone, and carry the stones up the slope with as little apparent effort as when moving downward.

This, however, must be an easier task than transporting them from distant sites or from their interior beds up the galleries to the surface. The space traversed in

this underground portage is sometimes equal to a perpendicular distance of nine feet, which has little mechanical relief from the inclination or roughness of the gangways. Some of the pebbles have from six to ten times the weight of their carriers. I never saw any copartnerships in these portages. No ant came to aid a struggling worker, and none seemed to need assistance.

I have often admired the vigor and skill shown by baggage-porters in shouldering and bearing up several flights of stairs the immense trunks which American ladies take with them on their travels. But here, if we may be indulged in the comparison, is an insect three-eighths of an inch long (and the worker-minors are shorter), who can carry up sharp inclines and perpendicular surfaces, over a distance three-hundred times its length, a burden six to ten times its weight. If, as heretofore, we estimate the average man at five and a half feet in length and one hundred and fifty pounds in weight, our baggage-porter would needs carry a half-ton trunk up one-tenth of a mile of stairway, to meet on equal footing the emmet athletes of the occident ant-hills!

The simplest type of ant architecture, as we have seen, is a single cave excavated in the earth, or in wood, or formed by detritus cemented by salivary secretions. This grows into (second) an enlarged chamber or chambers, with vestibule and connecting galleries. Thence (third) developing downward, the simple cave or connected chambers have grown into vast and deep-storied rooms and avenues, like those of the agricultural, occident, honey, and cutting ants.

Expanding in the opposite direction—a development upward instead of downward—(fourth) the little heaps

of earth-pellets (Fig. 21) thrown out around the gate of the cavern home of Pheidole, or the garden Lasius, become (fifth) the great conical structures of the mound-making ants of the Alleghanies, which are in themselves true habitations. This is an important difference. The cones are thoroughly honeycombed with avenues and rooms, streets and galleries, which are the actual living-quarters of the commune, and form, each mound in it-

Fig. 21—LITTLE HEAPS OF EARTH-PELLETS THROWN UP AROUND THE GATES OF PHEIDOLE PENNSYLVANICUS, THE SIMPLEST TYPE OF ANT-MOUND

self, into a densely populated city, although in full alliance of citizenship with all like mounds in the vicinage.

We come now (sixth) to a type of structure which characterizes a number of genera in Europe and America, but which is particularly developed in various species and varieties of Cremastogaster. The species of this genus are small, and are widely distributed throughout our territory. They have a heart-shaped abdomen or gaster, flat above and rounded below, and this they have the odd habit of turning up and directing forward

(Fig. 22), so that it is almost parallel with the line of the thorax. [McC. 9, p. 188.]

These ants, besides nesting in the earth near the surface and under stones, are apt to choose a site in a heap of stones, on an old stump, or in the débris of fallen and decaying logs. A colony settled among the crannies of a bowlder wall at our country home, Brookcamp, had built a covered approach to their main entrance, using therefor particles of dust, earth, etc., that had accumulated upon the rocks. The nest itself was within the interstices formed by the rounded exteriors of the big bowlders, and was quite out of sight. This covered vestibule was a mild suggestion of the vast mud-covered ways made by the Eciton, or "driver ants," to cover their route when out upon one of their devastating forays.

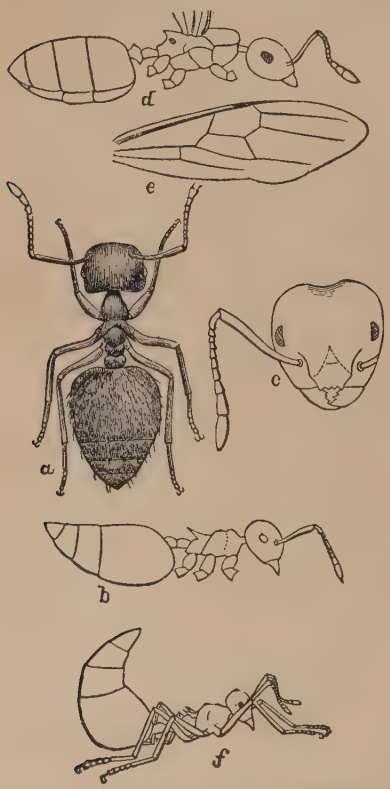


Fig. 22—CREMASTOGASTER LINEOLATA
a, *b*, *c*—Worker. *d*, *e*—Queen.
f—Worker with turned-up gaster.

On a vine twined about the cloistered porch connect-

(By courtesy of the American Museum of Natural History)

Fig. 23—CARTON COCCID-TENT OF CREMASTOGASTER LINEOLATA-PILOSA PERGANDE. (After Wheeler)

ing my city manse with the church, I have noted similar enclosures built around the stock at points where a branch diverged therefrom. They were apparently wrought out of "carton"—that is, a combination of wood-dust, loose earth, minute particles of straw, hay, and horse-feed (the droppings of passing animals), such as drift from the street into corners and crevices of walls and upon the foliage of city plants (Fig. 23). This material had been mixed into a sort of mortar and fixed by a natural cement secreted by the ants, until it formed a woody composite that easily crumbled between the fingers, but held together well enough to answer its purpose as a temporary tent. Structures of a similar character have been observed around the bases of the needle-like leaves of pine-trees in New Jersey and elsewhere.

To what purpose are these rude shelters made? Chiefly to obtain exclusive and undisturbed possession of aphides and other insects that excrete the honey-dew of which they are so fond. [W. 9, pp. 1–18, Plate ii. copied.] This enclosure not only serves to restrain the insect herds from wandering to inconvenient sites, but shuts out alien ants that, when strolling about, as is their wont, in search of food, might happen upon the pre-empted aphidian flock, and encroach thereon. In short, it is the Cremastogaster's way of "staking her claim."

It is interesting to notice that this tendency to build carton tents exists in this species not in full vigor as a thoroughly developed and fixed habit, but as a subsidiary tendency, a survival, it may be, of an ancestral habit once strong and persistent, but which, in course of time, has been gradually weakened and well-nigh

Fig. 24—PASTEBOARD NEST OF DOLICHODERUS BITUBERCULATUS MAYR, FROM BANKOK
(After Forel)

atrophied. Still, under the stimulus of special favoring conditions, the latent ancestral tendency springs into active force, and shows itself in the occasional and temporary structures above described.

I have alluded to this phase of ant industry and ventured on the suggestion of its origin, not simply because of the intrinsic interest of the facts, but because they lead up to what is (seventh) a distinct and well-defined form of nesting architecture. Not only Cremastogaster, but other genera have acquired the habit of making carton nests in and upon trees. They are at times quite large (a foot or more in diameter), and they form true habitations, as are the nests of hornets, in which larvæ are reared, dependents housed, and all the functions of an ant commune carried on.

These tree-dwellers are for the most part habitants of tropical and subtropical countries, and the accounts of travellers give one a vivid conception of their power, when excited by intended or accidental aggression, to swarm forth in legions from their domiciles and punish invaders with stings that seem pointed with fire.

Of the ants of this form of arboreal nest, Fig. 24 is taken from Dr. Forel's *Ants' Nests*, and shows a pasteboard nest of *Dolichoderus bituberculatus* Mayr, taken from the bough of a tree from Bankok, Siam. Fig. 25 is a tree-nest after a figure published by Dr. von Ihring [Von I. 1, p. 334] of *Camponotus rufipes*, of South America.

We come now to note (eighth) the existence of nests for which the framers have called in the use of silk. That this should turn up at even the most unexpected points in the insect world will not seem strange to one who knows how largely the spinning habit enters thereinto. Many ants in their larval forms follow the rôle

Fig. 25—NEST OF CAMPONOTUS RUFIPES ON A TREE
(After Von Ihring)

of other orders, and spin themselves within their tough pupa cases or cocoons. Thus we are quite prepared to learn of Professor Forel's Ceylon species (*Polyrachis jerdonii*), which builds upon leaves a small nest composed of pebbles and minute fragments of plants, cemented together by a fine web, or woven together to form a web-like wall of bright grayish brown. In the East Indian ant *Polyrachis dives* the nest wall is a pure silken web of a brownish yellow, by which the enclosing leaves are lined and bound together.

Polyrachis spinigera, of Poonah, India, makes for its nest a fine brown silk web pliable as the finest gauze, but thicker. This is fixed on the ground, where it forms the lining of a funnel-shaped cave that widens out into a chamber.

But among the woven ant-nests thus far made known the one that seems to show the highest type of nidification is that of *Æcophylla smaragdina*, a common ant of tropical Asia and Africa. The workers are large, long, reddish to greenish in color, of a war-like and fiery temper. Their females are grass-green, their males black (a rather striking color combination), and they maintain populous communes among the branches of trees. The common habitation is formed by joining together the borders of leaves with white spinning-work and binding them into a large mass, something after the fashion of certain spiders and tent-caterpillars.

According to Mr. Aitken [Ai. 1, p. 422], the method of construction is as follows: A worker stands at the point where two adjoining leaves diverge, and holding to one with its claws, seizes the other with its jaws and draws the two together. As the leaves gradually approach each other they are held in place by the outspun threads,

until, as the leaves touch and overlap, they are overspun and firmly bound down. And so the work passes from leaf to leaf until a sufficient housing is provided. This process in essential method resembles that which I have studied among spiders, particularly those large native orb-weavers, like *Epeira insularis* and *E. domiciliorum*, that build as a domicile large leaf-tents above their great geometric orbwebs.

It seems almost past belief as a bit of natural architectural ingenuity, but the observer, whom Professor Forel thinks entitled to credit, states that if in clamping the leaves the space separating the edges be overwide for one ant to manage, other workers, from two to five in number, will "join hands" to form a chain, each grasping the body of its neighbor until the last link on one side holds a leaf in its mandibles, while the last link on the other side grasps a leaf with its claws. Thus, all drawing together, the chain is gradually shortened until the breach is closed and spun over. When enough leaves have been fastened together, the whole is overspun with a compact silk web, and made water-proof. It is then divided into connected living-rooms as required.

Many ants are opportunists in the choice of a habitat. Instead of working out a nest in earth or wood, they exercise a sort of "squatter sovereignty," and preëmpt for use some available locality. For example, I found a large commune of *Aphenogaster tennesseensis* in an old pine-tree stump at Bellwood, Pennsylvania. Moss and lichens grew freely upon the stump and its great bare roots. In the scant soil that had formed upon the top sundry wild plants were growing, as in a roof-garden. At various places over the surface large, dry

toadstools were attached, looking like ancient sea-shells. Within these the ants had settled. The interiors swarmed with workers and larvæ; and, as evidence that the task of enlargement was going on inside

Fig. 26—NEST OF PSEUDOMYRMA BELTI ON MEXICAN ACACIA THORNS

of both toadstools and stump, the outer bark of one large root was covered with fresh wood-dust.

In tropical and subtropical countries examples of this habit are common on certain thorn-bearing trees and shrubs, as the Acacia. These thorns are often quite formidable in size. I have had specimens of them which had been inhabited by ants of the widely spread genus Pseudomyrma. Near the points circular gates were cut out for entrance and exit, and the commune was established in the hollow interior (Figs. 26 and 27).

Fig. 27—PSEUDOMYRMA BELTI (EMERY) MAGNIFIED

It is believed that some ant-inhabited plants, as *Cecropia adenopus*, furnish in themselves a supply of

food in small pyriform or ovate albuminous growths (Müller's corpuscles), which are eaten by the insects, apparently without disadvantage to the tree. They present another example of that interesting form of symbiosis—a comradeship of support and defence—which not infrequently exists between plants and insects.[1] For in return for the nurture yielded by the plant, the ants protect them from the incursions of such enemies as the leaf-cutting Attidæ, that defoliate them in their leaf-hunting expeditions.

Our studies of what, for lack of a fitter name, has been called the "architectural" and "engineering" skill of ants will now return for a while to the great confederacy of the communes of mound-making ants. Let us note the citizens of this large colony of *Formica exsectoïdes*, who are adding a story to their communal cone. It is a lively and interesting scene. The utmost activity prevails, greatly quickened by a smart shower which has made the building material more available for use; for hot, dry weather had left the soil powdery and unmanageable.

We soon get an insight of their mode of operating. On the outer surface, especially around the gates, small warts or pillars are thrown up, as though to gauge the height of the addition; and between these the infilling is made with pellets of earth, most of which are brought from the interior, where new galleries and rooms are being excavated. The vehicles for this portage are the insects' jaws, that serve alike for carriage, as basket or barrow, and for digging, as pick and shovel. The irregular faces of these pellets fit into and fasten upon one

[1] *See* Prof. A. F. W. Schimper's *The Varying Relations Between Plants and Ants*, Jena, 1888.

another, uniting the whole in a way that, perhaps, may not be characterized as "dovetailing" or "ball-and-socket" jointing, but which raises the suggestion of such contrivances.

It is said that formic acid, which is extruded freely by ants, forms with silica a natural cement. Can it be that these pellets, which are composed largely of sand, are thus cemented together? Probably not; but at least the moisture of the late rain has aided their adhesion. Grass straws, cut from tufts growing along the base and strewn over the summit of the cone, are dragged into place and skilfully wrought in with the pellets. Besides these, bits of decayed wood, the needle-like leaves of pine-trees, which are abundant here, and leaves of low shrubs are intermixed with the soil. These insect masons are not forced to the hard service laid by the Pharaoh upon ancient Israelites of making bricks without straw.

At another hill the builders had undertaken a special work of construction, or, rather, of repair. An errant cow grazing on the mountain-slope—we can hear the tinkle of her bell from a distant corner of the wood—had strolled by that way and set a hoof upon the edge of the mound, leaving a deep and wide impression. Just one; for a swarm of irate insects must have instantly attacked Brindle's legs and caused her to beat a rapid retreat. But she has left a footprint on the cone that must needs be repaired. As a full day's work is before us, let us bring camp-stool, note-book, and drawing-pad, and sit down before it. We shall see something that looks like a well-planned system of engineering in filling up the hole.

The cow's foot had made a nearly circular pit between eight and nine inches in diameter and depth. At the

unbroken edge of the pit the task of filling up had begun. From the lower points (A) there extended a series of elevations (*a*, *b*, *c*, *d*), which marked the upper outline of an arc. Beyond this, toward the base of the hill, and parallel with it, was a like series (*d*, *e*, *f*), bending around the depression next to and parallel with its

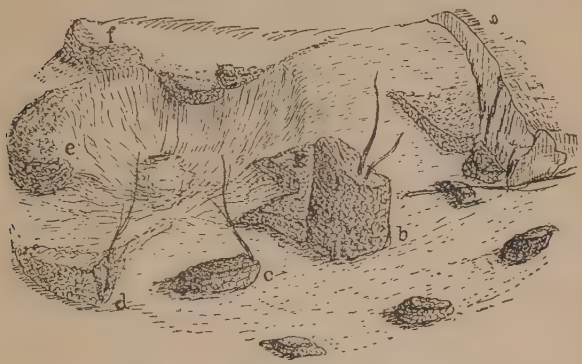


Fig. 28—PRELIMINARY ENGINEERING
Mound-making ants filling up a break made in a mound by a cow's foot

lower rim. These little pillars were not alike in shape, and it was quite noticeable that their height gradually increased from the unbroken margin of the mound toward the centre, where it was highest. Yet, throughout, their tops conformed to the general surface of the cone, the diminishing depth from centre to edge being met by a corresponding lowering of the columns. From these, and from similar elevations around the rim of the track, as centres of operation, the work of covering-in proceeded with great advantage (Fig. 28). A number of straws were worked into the columns apparently as braces; and in one of the little hollows were piled many shells of cocoons from which antlings had just been

delivered, and which previously had been carried from the hill and dumped among the stones outside. Within three days, so vigorously did the work go on, two-thirds of the track had been filled up. The new work did not connect with the broken parts on the side toward the summit, but a deep trench, or open gallery, was there preserved all the way across. This seemed strange until it was considered that it was needful, or at least convenient, to keep such an opening into the network interior of galleries in order to allow easy entrance to and exit from the works within the track.

Could this systematic order of work, with such plain marks of an intelligent plan, and carried forward much after the manner of men, in their like though larger undertakings, have come about by mere chance? It does not seem reasonable to think so. Yet there was no trace in any quarter or in any act of chief-engineer, or local foreman, or gang-boss, or of any visible organized directing body, or official supervisor, or regulator, or prompter. Every individual had a mind to work, and every one wrought, but unprompted and ungoverned save by its own impulse.

Here, also, the observer was impressed by the presence of that invisible, secret, mysterious Something—which he has called the Spirit of the Commune—beyond the veil of science and philosophy, which kept all these active sovereign integers in such harmonious co-operation in the execution of a fixed plan, sustained without intermission for half a week. Is analogous action possible among men? And if not, why not? And wherein lies the superiority—if it be superiority—in this respect of ants over men?

Everywhere we note examples of this co-operating

instinct of construction. In order to get a view of the interior of an ant city a mound was sawed through the centre with a large cross-cut saw and one-half thrown aside with shovels. This required vigorous and rapid movements to avoid the attack of the myriad of angry insects thus assaulted in their home. This, however, was less formidable, because the calamity was so unique and terrible—like the earthquake shocks which lately wrecked Charleston and San Francisco, Messina and Reggio—that the ants at first seemed stunned, and moved about as though distraught. Such an overthrow was beyond their limited powers to grasp. But they soon rallied, and promptly set themselves to restore their ruined commonwealth. Yet the blaze of passion was hot enough on the part of those who swarmed from the quarters untouched by the shovellers. Fortunately, the heat and fury thereof were soon expended.

Let us examine the interior of the mound thus laid bare. The view of the perpendicular face of the half-cone exposed was truly remarkable (Fig. 29). Tubular galleries three-eighths to half an inch wide rose in regular series one above another, from the base to the domed summit. The cone within was a rough reproduction in soil, and on a gigantic scale, of the celled structure of the combs of bees, wasps, and hornets.

Throughout this network of galleries were scattered cavernous rooms, the common lodging-places for the young and other dependents, although the galleries also served this end, as well as being the roadways between all parts of the community. It is an amazing structure for so small a creatureling, and must have required immense labor and pains to rear it. That this huge hill of sandy earth, mixed with and fixed by vege-

table matter, and perforated from top to bottom and from side to side with numberless tubes, could be made to stand the stress of mountain weather—rains and floods, frosts and snows—was marvellous. The inference

Fig. 29—SECTIONAL VIEW OF ANT-MOUNDS

seems inevitable that some sort of hardening material must have been used—secreted from the jaws as saliva, or extruded from the stinging organs—at least upon the inner surface of the galleries. But, however done,

the ants had successfully solved their problem of building a stable structure with friable materials, and had wrought it into a true communal home.

To further learn their method, let us fix attention upon one point. A small cavity with a bit of projecting clod on the foundation of the removed part, and close to the remaining one, was the centre of active operations. Just above towered the perpendicular face of the half-cone, along which everywhere squads of workers were

Fig. 30—ANT ENGINEERING
Covering-in a broken horizontal gallery and repairing a broken vertical one

continually thrusting their brown heads out of gallery openings and dropping pellets of soil. They were clearing up the inner débris from the broken passageways, and doubtless some of them were calmly carrying forward the improvements begun before the "earthquake" (Fig. 30). These pellets were taken up by the workers beneath, who for some reason best known to themselves seemed to prefer them to those that lay

everywhere around them, the crumbled particles of their shattered home. Two galleries running side by side, the upper parts of which had been destroyed, were being covered over. They were directed along the bottom of the cavity for three inches, and then slanted upward to connect with the standing half-cone.

The work progressed by continuously adding earth-pellets to the outer edges and pressing them into place. As the sides rose they were gradually arched, and the springing of the arch was plainly seen. The curved edges approached in irregular lines, and at various spots the two projecting points drew near and nearer until they almost touched. It was quite exciting now to watch the delicate manipulation of the masons. Here came a worker with a pellet of larger size than usual. She climbed the arch, moving more daintily as the top was reached. Holding on the while with her hind feet, she stretched across the wee chasm and dropped the ball of soil into the breach. The bridge was laid!

And now, with surprising rapidity, it widened as the roof of the arch was covered. Until this was done, openings were left through which the ants moved back and forth, and which were closed over as sections of the arch were completed. They were temporary arrangements—"manholes," so to speak—for the convenience of the builders. Through these one could see the ants at work upon the inner surface, smoothing it with their jaws, as a mason would work with his trowel and mortar. The outside of galleries and rooms was left rough, as laid, but the interior was smoothed. Salivary secretions probably gave the additional moisture needed for this. At one point the gallery was widened from

half an inch, the usual diameter, to one and a half inch, as though a store-room or living-room were being formed. Close by, a vertical gallery, one side of which had been torn away, was being repaired by the infilling of the broken side, and this work was done precisely as in the case of the horizontal arches.

One was reminded, in all these actions, of the methods of bricklayers at work upon an arched sewer or culvert, or of masons putting up a rubble-stone wall. There were some marked differences—the profound silence of the worker ants and the absence of overseers. The ant is no "spendthrift of her tongue." She "talks to us in silence." No one is prompted or driven to work; no one needs to be, for here there are no shirks. No regular hours of service are kept, and there are no fixed intervals of rest. Labor goes on all the time; and, viewed in the mass, there is no cessation, at least at this juncture, by day or night. Each individual determines for herself the period of work and the time for rest, and so strong is the sense of duty, or the instinct of fidelity, in every ant, that such individual liberty and responsibility are not abused, and the public works of the commonwealth are not damaged or delayed.

Building operations were not limited, as in the above cases, to the original site of the cone. A fragment half the size of one's head, which had been shovelled to one side, was a centre of special activity. It had already been made the nucleus of a new mound. Columns, corridors, and halls, corresponding closely with those outlined upon the under side of the fragment and united therewith, had been erected. In one of these halls was a small collection of dead ants, a token of a custom sometimes observed among these insects to show a sort

of funereal respect to the dead of their own household (Fig. 31).

This was one of the most interesting and puzzling of the activities developed by the cutting-down of the mound. Access to the uninjured part was easy, and

Fig. 31—MOUND-MAKING ANTS COVERING A DOUBLE GALLERY

a, a, a—Double gallery. *c, c, c*—Chambers.

knowing the habits of these Formicans and their wide range of daily venture, it seemed strange that they did not at once, as did so many of their fellows, rally to the reconstruction work on the old foundation. Had they been found huddled impassively underneath the scattered fragments, keeping refuge for the nonce and waiting results, it would have seemed natural. But this immediate launching upon an apparently fresh enterprise—turning to housemaking instead of home-repairing, so near the gates of the old republic beginning the upbuilding of a new —this mystified a mere human brain. Did the familiar savor and associations of a bare lump of their former home deceive them? Were they so little

impressed by the commune's partial wrecking as to think that nothing serious had happened? Was this an instinctive act of self-protection, for the present exigency alone, a sort of bivouac and makeshift, like the temporary camps around a despoiled city? Would these adventurers persist, and build up a permanent seat, or soon return to the old quarters? Was this a proof of superior wisdom, the act of keen opportunists quickly adapting themselves to strange conditions, or of faculties far more limited than we have been wont to credit to ants? Was it simply the result of a physical necessity to be doing, an uncontrollable impulse finding vent in action?

But here we stand, vainly speculating and philosophizing, while the field of observation just before us is alive with busy insects who have much to show us. Let us go back to the practical and objective. We have seen something of the way in which the citizens of an ant community labor in mass on their public buildings and roads. The manner of the individual now requires to be noted. And here comes a worker-minor who will answer our quest. She has strolled along over the irregular surface of the old foundation of her home, feeling with her antennæ here and there without any visible purpose. At last she pauses. She seems to be reflecting upon the ruin around her and without apparent emotion. Ah! if we could but command the mediation of some fairy interpreter of her thoughts!

But see! Suddenly she leaps upon a pile of earth-crumbs, and, seizing one in her jaws, lays it down at a little distance with a sharp pat. Another and another and many others follow, all gathered and placed with amazing activity. The little body, from the tips

of her ever-moving antennæ to the apex of the abdomen, quivers with the intensity of her energy. She reminds one of a small harbor tug, forging ahead, trembling from stem to stern under her great engine as she draws in her wake a huge ship. Only, there is no puffing! All goes on "in solemn silence," like the shining orbs in "the spangled heavens," as sung in Addison's paraphrase of the nineteenth Psalm.

Will the day ever come when even a remote approach to this noiseless toil shall characterize human communes? To be sure, since men's work is so largely wrought by the aid of machines, the racket thereof and the audible strain of their motors cannot be wholly subdued. But it is certain that some of our mightiest and most effective machinery does its work with the minimum of friction, and so of noise. Really a mechanical contrivance might be fairly counted valuable in proportion to the silence of its operation. Always force is wasted in noise—physical and mental as well. Silence is a mighty economist of man's wealthiest powers. Racket is a ruinous waster.

Beyond doubt, at least, abatement in large degree of our city noises is not only desirable, but wholly practicable. They are needless. They are wasteful. They are often cruel to the invalid and nerve-worn. They are remainders of a crude stage of development, and an enlightened people should not tolerate them. They are chiefly the products of thoughtlessness, stupidity, penuriousness, unthrift, and a selfish rudeness. Here also our city magnates and lords of industry might go to the ant and consider her ways with profit.

CHAPTER III

ENGINEERING METHODS IN ANT STRUCTURES

WE return to our lone pioneer laborer of the mound-making ants, left, at the close of the last chapter, in the act of beginning a work of repair upon her desolated commune. Her movements will give us an insight of some emmet methods in this field of engineering construction. One soon begins to see some purpose in her work, for slowly the suggested outline of a gallery takes shape. Meanwhile a second ant has wandered that way. She halts and, with what appears a careless mien, surveys the scene. Then, struck by an impulse that probably is as mysterious in its origin to her as to her observer, she joins the first adventurer in her attack upon the pile of earth-pellets and in their transfer to the growing gallery. By a like process the squad of workers increases from two to four, from four to ten, from ten to fifty or more, until a busy company swarms over the works, which are rapidly taking distinct form as an arched gallery.

The pioneer of this enterprise has long ago been lost to sight among her comrades, and one regrets the lack of brush and white paint wherewith he might have marked the black abdomen, and thus have kept track of her. It is certain, however, that the fact of her having been the first citizen and founder of that settlement had given her no claim to authority or superiority of any

sort. Her fellow-citizens seemed ignorant of the fact, and it is doubtful if she remembered it herself. Such sentimental considerations have no weight in this wholly utilitarian government and society.

Perhaps this is she who slips out of the throng, and, ascending a bit of a clod hard by, squats upon her hind legs and begins to preen her downy coating. What to her now is all the busy scene beneath her? Let the emmet world wag on as it will; she must be clean. And so, in peaceful unconsciousness of all and sundry in her sphere of being, she proceeds with the one present purpose of life, and thoroughly cleanses herself in the approved mode, as hereafter will be described. And now, her purifications being finished, she yawns, stretches her limbs, gives her antennæ a final brush, and leisurely descends from her perch. A moment she stands as though undecided, then plunges again into the whirl of activity on and around the new works, and soon is indistinguishable from her fellows.

In the review of these building operations several reflections arise. Here was a test of the ability of ants to meet a new experience, such as was the destruction of one-half of their republic. Accidents like the breach made by a cow's foot they had known and remedied, but no such misfortune as then faced them had ever befallen. Yet they met it with admirable spirit and method, and with success. They set themselves at once to the work of reconstruction, not only with vigor but with practical wisdom, and with ready adaptation of means to the new conditions. Their instinct was sufficiently elastic to cover a strange and colossal adversity; or, may we infer that the appeal in the emergency was to something other than routine instinct

—something, in fact, that nearly approached and certainly suggested a process of adapting means to ends, that bore the earmarks of reasoning?

Again, their swift and perfect reaction from the first shock and excitement of a disaster that well might have overwhelmed ambition and endeavor was noteworthy. They went straight on with the ordinary duties of life in the uninjured part of their city, and took up the extraordinary ones without a sign, understandable by human intelligence, of grief, or passion, or discouragement, or deep emotion. No time was wasted in useless moping, no vigor in aimless schemes. At once they aroused themselves to action, and attacked the emergency with admirable energy and poise. Among men such self-control has been called the fruit of philosophy. If such it be, will we be able to deny our mound-making ants the title of insect philosopher? Certainly they are apt—are they automatic?—imitators of the philosopher's rôle. And not to a few rare spirits, the sages of the commune, but to all and equally is the honor due. Nature maintains in the ant city Voltaire's ideal condition that a philosopher should live only among philosophers.

A curious observation as to how active work may affect the physical condition of ants was made upon three mounds listed for daily special study. For several days they were found in such an unusually excited condition that they were down in my note-book as the "hysterical hills." The cause of this agitation evaded all inquiry, but the cure was most interesting. Rains that succeeded the first dry days of our coming were observed to have imparted activity in building operations to a number of mounds. The prediction

was thereupon ventured to one of our company that we should find our "hysterical hills" busily building up their cones like their fellows of other mounds, and as a result settled into their normal composure. And so we found it. They were working at the top of their bent, and were subdued in temper and manner. Honest, hearty physical toil had quieted them, as it often does over-nervous human beings; or, perhaps it had filled their natures with a present and pressing duty, thus diverting them from that useless expenditure of force that often comes from purposeless inaction.

One must also note the immensity of the labors wrought by the insects. These may seem trivial as one watches them lifting up and placing here a pellet and there a pellet of soil, and building them into the walls of the common structure. But if the results be considered, they will seem astonishing for such small creatures to accomplish. Perhaps a comparison with a noted building achievement of our race, the great pyramid of Egypt, may here be allowed. It is true that such comparisons are apt to be superficial and misleading, but from a purely popular standpoint they are allowable and may be instructive. The cubic contents of one of the largest mounds was calculated to be in round numbers two million cubic inches. We may estimate the bulk of an ant to be equal to that of a cylinder three-eighths of an inch high and one-sixteenth of an inch in diameter. Taking thirty-five one-hundred-thousandths of a cubic inch as the bulk of a single worker ant, the size of the builder would be to the size of the edifice as one to fifty-eight hundred million. Let us compare this with a corresponding estimate of the work of man, taking his bulk as six cubic feet, and accepting the solid

contents of the great pyramid as reckoned at seventy-six million cubic feet. We shall have the following formula of comparison:

Man's bulk to his building is as 1 to 12½ millions;

The ant's bulk to her building is as 1 to 5800 millions.

A simple calculation will show how greatly this exhibits the comparative superiority of the insect in the mere quantitative results. It should also be considered that in these and all other such works the ants have no mechanical appliances such as multiply the effect and ease the fatigue of human labors. Her sole tools are her jaws and feet (Figs. 32, 33), the bodily appendages with which nature has provided her, although it must be admitted that these are highly effective.

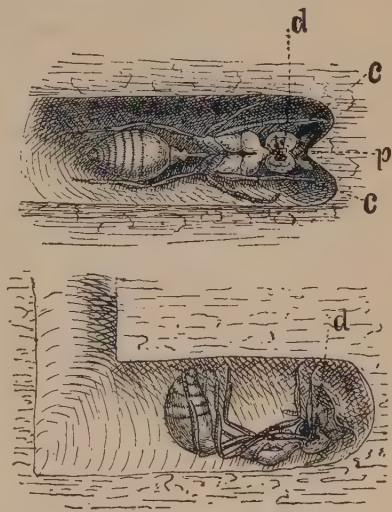


Fig. 32—ANTS DIGGING OUT GALLERIES
(Drawn from an artificial formicary)
c—Claws. *d*—Particles of dirt.
p—Point being dug out.

There is another comparison—in sooth it is a contrast—which needs here to be drawn. Such knowledge as has come to us of the building methods obtaining in ancient Egypt shows that the laborers were driven to their hard tasks by overseers who urged on gangs of workmen with the lash. Theirs was unwilling service,

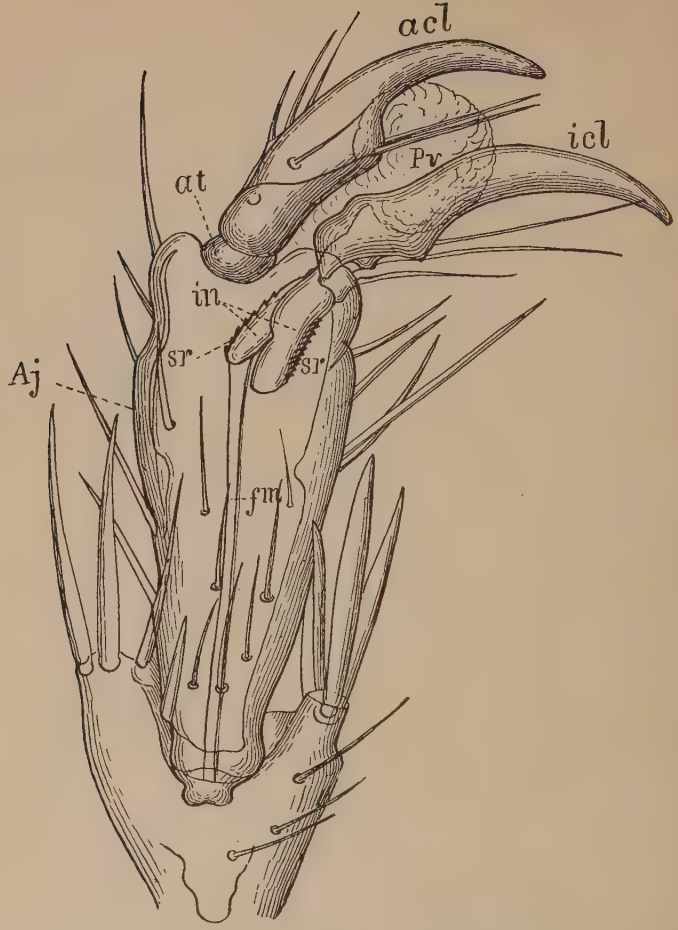


Fig. 33—AN AGRICULTURAL ANT'S FOOT, ENLARGED 180 DIAMETERS: THE TOOL USED, WITH THE JAWS, IN DIGGING

a c l—Attached claw. *a t*—Its articulation with the joint. *i c l*—Inserted claw. *i n*—The inserted parts. *s r*—Serrations on same. *f m*—Foot muscle. *p v*—Pulvillus or foot pad.

cruelly exacted. We have already seen that the ants rendered free and willing service, and that their toil was without overseers, and wholly of individual selection. From the beginning to the end there was no discord among them; no protests; no strikes, sympathetic or otherwise; no walking delegates or their insect analogues; no oppressing (or oppressed) contractors or owners. Indeed, there was no occasion for any of these frequent appendages of great modern structures whereon human workingmen—artisans, mechanics, and common laborers—are engaged.

And yet the work was done, and on undertakings relatively many times greater, in the most perfect harmony, good temper and content of all. Is it possible for man to draw some lessons from this example of natural civics? Is it beyond hope that some goodly measure of such results may lie within the sphere of the practicable for our current organized society? Does our "civilization" hopelessly encumber us from ever attaining the ideal commune? Must it lie in the bright cloud-realm of the optimist's dreams, until—alas! can it ever be?—the whole race, reborn and disenthralled, shall return to the unsullied simplicity of nature?

It may be drawing too fine a distinction in the building work of ants to discriminate between architecture and engineering. Yet we seem to note such a distinction. The commune of the agricultural ant, already described, is differenced from its fellows by the circular disk (Fig. 34) that surrounds its central gate or entrance. The construction of this disk, and its maintenance as a free and open plaza in the midst of the surrounding subtropical foliage, are works for which no little skill and energy are required (Fig. 35).

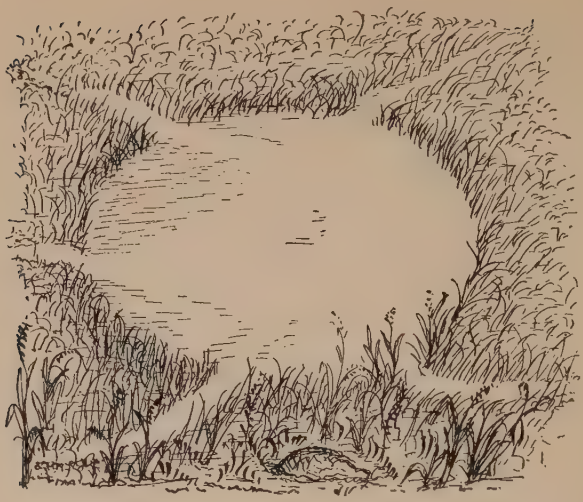


Fig. 34—THE CIRCULAR DISK AND ROADS THAT SURROUND THE ONE CENTRAL GATE OF THE AGRICULTURAL ANT OF TEXAS

But this is only the beginning of the enterprise, the pivot upon which more important undertakings centre. At various points around the circumference of the disk enter a series of cleared trails, widest at their point of contact, that radiate into the surrounding herbage, whose denseness at once suggests the reason for their construction. In short, they are roads laid out to penetrate the harvest fields of these granivorous ants, and are used and admirably adapted for that purpose.

The method of transportation in use by harvesting and other ants is primitive enough, consisting simply in personal carriage by a host of individuals (Figs. 36, 37, 38). It is the method of the African explorer, the method of primitive man when unable to utilize the beast of burden. But it is effective. It is here that the engineering quality of the roadways comes in; they

converge upon the entrepôt of the colony. They facilitate transportation by making communication easier and quicker. However they may have arisen in the history of the harvesting habit's development, or with what purpose (if any) originally constructed, the facts are as stated.

And they do not stand alone. In the summer of

Fig. 36

Fig. 37

Fig. 35

Fig. 38

Fig. 35 — AGRICULTURAL ANTS CUTTING GRAIN TO CLEAR ROADS AND DISKS

Fig. 36—ANT CARRYING A PELLET OF SOIL

Fig. 37—A SPECIMEN OF GRAIN-STALK ON AN ANT CLEARING

Fig. 38—AGRICULTURAL ANT CARRYING GRAIN-STALKS

1887, while visiting Scotland, I spent two days at the Trossachs Hotel, which is located in the glen known as the "Pass of Achray," through which flows the little Achray river (or creek) which Sir Walter Scott describes as "the stream that joins Loch Katrine to Achray." Here I found a number of nests of *Formica rufa*, the well-known "horse ant," or "wood ant," of Great Britain. They were built on either side of the footwalk that leads from the Trossachs glen to "the sluices," as they are popularly called, which regulate the stage of water in Loch Katrine, the source of supply for the city of Glasgow. The demands of humanity are imperative; but the lovers of romance cannot but mourn that the spell which Scott's genius has thrown over such beautiful spots as "Ellen's Isle" and the "Silver Strand" is being dissolved before the engineer's need for greater water-storage capacity.

The mounds raised by the rufous ants were found to be cones of earth intermingled with chippage of various sorts. They were about three feet high, and some of them from six to seven feet in diameter across the base. They resembled those of our mound-making ants of the Alleghanies in general appearance, but their builders seemed to make a freer use of leafage and chippage to work up and cover their nests. The surface was quite thickly thatched with bits of straw and leaves, stalks of grass, pieces of fern, and various like materials. Numbers of openings appeared upon the surface at irregular intervals from the summit to the base, and at 4 P.M. many workers were dragging the chippage back and forth, as though arranging to close the doors for the night. [McC. 23, p. 336.]

These huge cones stand in the midst of the tall

bracken—a large, coarse fern that overhangs them, and at times almost hides them from passers-by, as a forest might hide a castle standing in its midst.

My attention was especially attracted to the character of the roads leading from the ant-hills to various points in the surrounding wood. These were distinctly marked upon the surface of the ground, having in places a width of from two to four inches stained dark brown or black by the formic acid exuded from the insects as they passed along. The fallen leaves and crushed grass upon which the trails were made were pressed down and smoothed by the constant action of innumerable legs upon the surface. So well marked were these trails that they were easily traced even without the presence of the columns of ants that marched back and forth upon them.

While following up one of these roads, I was struck by the fact that it showed scarcely any deviation from a straight line. In order to test this matter more carefully, I selected a large mound from which three roads radiated. These were all traced to their termination at three several oak-trees, up which the columns of ants ascended to obtain the honey-dew supplied by numerous aphides that infested the branches. The roads were carefully marked out by stakes set at short intervals, a plan made necessary by the high bracken, whose stalks stood so closely together that they had to be pushed aside to trace the roads.

The following facts resulted: Road No. 1 was sixty-five feet in an almost perfectly straight line from the nest to the tree. Road No. 2 was seventy feet long and varied less than three inches from a direct line drawn from the nest to a point within two feet of the terminal

tree. There the column made a détour of about six inches. But an abandoned path continuous with the main road, which apparently had been used at a recent date, was traced for a considerable distance farther.

Road No. 3 was the longest, being more than a hundred feet long. It extended for nearly twenty feet in a straight line, at which point it touched an old stump that deflected it at a slight angle. Thence it was continued in a nearly direct course as far as a beaten footpath through the wood. Here the ant trail was obliterated by passing human feet, although the ants still thronged the pathway, there much broadened by the continual interference and loss caused by foot-passengers. The trail, however, was resumed at a point nearly opposite that at which it touched the path, and was continued again in a straight line about twenty feet farther to the tree where it ended.

When the entire trail (No. 3) was staked off, it was found that its terminus deviated less than three feet from the straight line drawn from the point of departure at the ant-hill. The greater deviation in this case was doubtless caused by the peculiar difficulties in the track. The three roads so radiated from the parent nest that they were included within about one quadrant of a circle, of which the two shorter trails might represent radial boundaries of the quadrant, while the longer trail was midway between the two.

Looking simply at the results of these observations, it is manifest that these rufous ants showed an accurate sense of direction in marking out and following their approaches to the trees. It would not be reasonable to attribute such mathematical accuracy as above shown to mere accident. The roads in point of directness were

as well laid out as are works of a corresponding nature done by the engineering skill of men. And these are not isolated cases, but mark the general rule. The mound-making ants (*Formica exsectoïdes*) of America, which so closely resemble *Formica rufa* in their architecture and general habits, show like characteristics in their road-making, though I do not remember to have seen it displayed under such difficulties.

The question inevitably arises, How did the ants manage to lay out these roads with such precision? When a corps of engineers or road-builders produce like results, we easily call up certain steps that have been taken. We think of two or more persons, provided with surveying instruments, all dominated by the sense of sight, and controlled by reasoning upon the facts and figures entering into the problem, making out certain lines, and, as far as conditions allow, laying out the course in a straight line between the points to be connected.

In the case of the ants we start under the embarrassment of not having the facts to reason from. Were the roads marked out at once, or are they a gradual growth? We do not know. Has the direct course been determined by a great number of experiences, of which the errors in direction were gradually eliminated, and the final result —*viz.*, the shortest path to the desired point—retained? We do not know.

It is easy enough to understand how, after a course has once been fixed, the ants follow it unhesitatingly. Their antennæ, which are continually waved before them and to every side, at once detect the strong odor of formic acid on the trail. This is a perfectly accurate guide, and beyond doubt it is thus that the workers pass

so swiftly and surely between points on the established route.

The sense of sight, it will be observed by the reader, is not here considered. It is probably a negligible factor, or at least does not appear to play a considerable part in determining results. The visual organs of ants are good as far as appearances show, and as compared with those of the winged hymenoptera, as bees and wasps, ought to contribute something effective toward a visual memory of the localities over which their owners operate. They may do so here. But myrmecologists seem at one in the opinion that the vision of ants is extremely limited; and if so, it could hardly have effectively directed them in laying out trails of such length as here considered.

Moreover, the great ferns referred to as closely enclosing and overhanging the ant-hills and the whole surrounding region would probably have hindered the effective exercise of vision, unless we suppose that the course of the trails was fixed in the early spring before vegetation began and the vicinage was quite open.

Suppose we indulge in a bit of speculation? Let us imagine that when the winter has so far broken as to allow the insects full liberty of out-door life, a group of workers start out from the parent commune to explore the neighborhood for food. After the fashion of their kind, we see them passing to and fro in zigzag lines, in arcs and parabola. They are thus storing their memories with impressions by which to localize their route and insure their return. Farther and farther, and by gradual recessions, they reach an oak-tree. To ascend it is a part of the natural inquisitiveness (and acquisitive-

ness) which so strongly marks these insects, and forms an important factor in the feeding of the commune.

A tree is a veritable bonanza for insects of various sorts at sundry seasons. The sappy exudations of the plant; the opening buds; the bleeding galls; the hosts of insects, as coccids and aphids, that infest various parts, and prey so freely upon its generous bulk that their superabundance yields a rich harvest for many other insects—one or more of these may attract our foraging scouts.

And now, full laden, they are ready for the return journey. Their path down the tree is easily traced by their ascending trail. The real difficulty must arise as they reach the ground and face the home commune. Yonder it lies; the general direction is not hard (for us) to determine. But amid all these involved crossings and recrossings, of their first outgoing trail, how shall they find a straight path home?

The author is loath to resort to the supposition of some occult power, although he believes in a divine Over-force as the one intelligent source of all creatures and all their actions. His own explanation (held without positiveness) is that, by means of the odors left during their approach and recognized by the sensitive antennæ, assisted, perhaps, in some degree, by visual impressions, the ants discern the general course of their trail. It may be also that a spirit of venture which possesses most living things, and a profiting by happy chances which befall, may aid in giving them the first bent homeward. Moreover (and I am inclined to emphasize this point), the home commune, as the central abode and scene of activity of a vast multitude of ants, must be a huge reservoir of formic fumes that strongly impregnate the

surrounding locality, and serve as a sense-signal that affects, even at a distance, the sensitive antennæ of the workers, and so points the direct way home. Thus it falls out that the return is apt to be far more direct than the outgoing.

The next outgoing naturally would be over a somewhat more direct trail than even their first return, and so, in the course of a few trips, the first indirections would be eliminated, and the trail established in its lines as when I saw it. Something like this, perhaps, may be a natural history of the method by which the ants perform what seem to us notable engineering feats in laying out their roads.

But there are cases which cannot be explained so satisfactorily. While studying the cutting ants of Texas, near Austin, I took occasion to follow up the underground routes of some of this species. A planter, in order to get rid of the depredations of an immense commune near his residence, had set his men to dig it up and utterly root it out. In order to reach the central nest he had traced the ants from a tree inside his home premises, which they had stripped of leaves, to a point six hundred and sixty-nine feet distant. The nest occupied a space as large as a small cellar, the lowest and main cave being as large as a flour-barrel. In this central cavern were great numbers of winged males and females, and innumerable larvæ and workers. From this point radiated the various avenues over which the leaf-cutters marched on their raids.

With the aid of a young civil engineer, I proceeded to survey the main course of the insects. For part of the way we had but to follow the diggings of the planter's laborers. For the rest, it was only necessary to sink

holes here and there along the estimated course to the main nest, and, when the tunnel was struck, take another bearing. These bearings were afterward handed to a friend,[1] who had them translated into a chart. In some places the tunnel was as deep as six feet beneath the surface, the average depth being about eighteen inches. At the "exit hole," four hundred and eighty-four feet from the nest, the tunnel was two feet deep. Besides this main way there were two branch tunnels, which deflected from the trunk-line near the country road, in order to gain entrance to a peach orchard one hundred and twenty feet distant.

This chart shows better than any verbal description the problem in underground road-making which the cutting ants faced and effectually solved. [McC. 6, p. 224.] It quite confirms their ability, at least, to achieve such an undertaking as described by Dr. Gideon Lincecum, who observed a raid made by a colony of cutting ants upon a garden situated on the bank of a creek that flowed between their nest and the garden. In order to reach the desired plants they drove a tunnel beneath the bed of the stream, and, ascending on the opposite shore, successfully raided the garden. [Li., p. 327.]

Gen. S. W. Fountain, of Devon, Pennsylvania, a retired officer of the United States army, recently (1909) related to me an incident that quite confirms Lincecum's statement. While stationed at Fort Clark, Texas, during the summer of 1879, with Troop "E," U.S. Cavalry, the troop garden, whose conduct was assigned to Captain (now Colonel) A. B. Kauffman, was so persistently raided by cutting ants, who stripped the vegetables of their

[1] The late Mr. Strickland Kneass, C.E., Assistant to the President of the Pennsylvania Railroad.

leaves, that the site had to be abandoned. It was transferred to a spot near by that was surrounded by an irrigating ditch, and, thus insulated, was supposed to be quite safe from emmet assault. But in course of time the cutting ants appeared within the island garden. The officers, supposing them to be the former troublesome community, concluded that they had entered by tunnelling beneath the stream. What other way? But Captain Kauffman, sceptical of their ability to accomplish such an engineering feat, resolved to investigate. He drained the irrigating stream (some four or five feet wide), dug up the bed, and traced the insects' trail from their point of entering the garden to the old nest on the opposite side. The ants had indeed tunnelled beneath the water, guided unerringly by their remarkable instinct in engineering.

I have no explanation to offer of the method by which the Attidæ accomplished these feats in subway engineering. The facts are given, and they are without question. But by what peculiar topographical sense or gift, or by what faculty or process they carried out schemes which compare favorably, relative powers and proportions considered, with underground roads and tunnels of our own species, this author confesses his inability even to suggest an explanation. One may see how upon surface trails the antennæ aid in fixing the direction of the ants' course. But it is not possible to see how they could aid in laying out tunnels underground.

We turn to another and widely different use of the engineering faculty. In earlier days the gates of great buildings and of walled towns were kept with a high degree of diligence and ceremony. This was warranted

by their relative importance in the military methods of the period. It has now wellnigh ceased, except as a quaint survival of mediæval ways in castle and town, or as a relic of military days and discipline. It is interesting to find among the communal habits of some species of ants a like marked attention to opening and closing the public gates. And this is not a mere survival

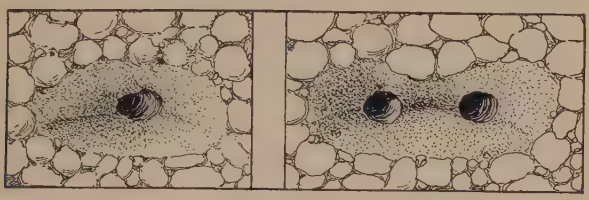


Fig. 39—OCCIDENT ANTS: SINGLE AND DOUBLE GATES OPEN

of a habit out of which the soul has gone, but is kept up seriously as an important part of the communal defences. Though the writer confesses that more than once he has found himself questioning its utility; which probably means his inability to perceive the same.

Among the communities most persistent in keeping up this habit are those of the occident ants, and examples of the custom as it obtains among them, and in one other species, will sufficiently illustrate the author's observations. In form the gates of Occidentalis are funnel-shaped openings through the gravel roof of the central mound into the interior, at an inclination of about forty-five degrees. There is usually but one gate, located about one-third of the way from the base. It is single or double, according as it opens into one gallery or two, the former being about three-fourths of an inch wide, the latter from one and a half to three inches (Fig. 39). Within, the terminating galleries are quite smooth;

without, they present the appearance of a rude stone wall in miniature. Around these gates gathers the daily out-door life of the ants. Back and forth through them citizens of the commonwealth are continually moving during the working hours of the day.

My observations throughout the latter part of July showed that the gates are ordinarily opened near or shortly after 8 A.M., but full activity of the colony did not begin until toward 9 o'clock. The general statement is warranted that the gates are opened between 8 and 9 o'clock A.M. This is not an early hour to go on duty for insects that have such a high reputation for industry. However, one must remember that the interior work of a formicary, which is very great, may be still going on behind closed doors. Moreover, I found that in a special exigency—as injury to a mound by floods—the ants modify their habit, and are found hard at out-door work at early hours.

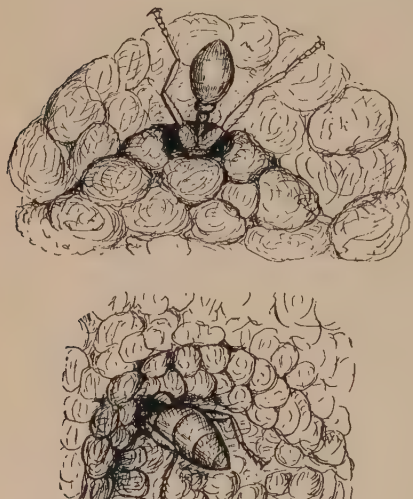


Fig. 40—OCCIDENT ANTS CLOSING GATES

The manner of opening a gate cannot be fully described, because the work is done chiefly within and behind the outer door of gravel. Doubtless the mode

would be shown correctly by reversing the process of closing gates (Fig. 40), presently to be described. What one first sees is a pair of quivering antennæ above one of the pebbles, followed quickly by a brown head, and feet thrust through the interstices of the contingent gravel-stones.

Then forth issues a single worker, who peeps to this side and that, and after compassing a little circuit round about the gate, or perhaps without further ceremony seizes a pebble, bears it off, deposits it a few inches from the gate, and returns to repeat the task. She is followed, sometimes continuously, sometimes at intervals of ten, twenty, even thirty minutes, by a few other ants, who aid in clearing away the barricade. After that, the general exit occurs.

On other occasions the method is not so deliberate, or at least it does not appear so. There is a rush of workers almost immediately after the first break, who usually spread over the cone, bustle around the gate, gradually widening the circles, and finally push out into the surrounding herbage. At first the exit hole is the size of a pea, and plainly shows that sand and soil have been used under the gravel to seal up the gate.

The process of closing gates is even more interesting to the observer than the opening, as the various steps are more under his notice. It will best appear by transferring from my notes a few records: About 6 this evening (July 19th) the closing of doors began. At nest A the work was chiefly from within. The workers pushed the sand from the inside outward with their heads. A grass straw about an inch long was brought from the interior and pushed out until it lay across the gate as a stay for the infilling material. Soil was here

used principally for closing, a few pebbles being added. The gate was not filled up quite flush with the surface of the mound. At nest B, which had a double gate, two workers-minor were the last and chief operators. They brought gravel from near-by parts of the cone and filled in the two openings flush with the surface.

At nest C, with a single gate, a worker-major was operating as at B. A number of ants had been engaged at first filling and gradually closing the inside, but all had retired within except one major. When the gate was nearly sealed a straggling minor came out of the grassy commons and essayed entrance. Several trials and failures followed, whereupon she commenced dragging dirt from the opening.

While thus occupied the major came up with a huge bit of gravel, which she dropped upon her comrade with as much nonchalance as though she were one of the adjoining pebbles. At last the minor dug out a tiny hole through which she squeezed into the nest, and the major, who was again deliberately approaching close behind, carrying another pebble, straightway sealed up the opening. During this amusing episode the straggler did not try to aid the closer, being wholly bent on entering, and the gate-closer paid her no attention beyond the first satisfactory antennal challenge. Each moved forward to her own duty with the undisturbed placidity of a machine.

At nest E by 6.30 P.M. most of the commune had entered the cone; at 6.45 the gate was being closed; at 6.55 only two ants were outside, slowly working at the gate, then half shut. An ant came out with a bit of straw, carried it to the refuse-heap, and returned. At 6.58 two ants came with chopped leaves, and at 7 P.M.

yet another. None of these attempted to help the gate-closers, who slowly and steadily filled up the entrance.

Now occurred the usual side-play with late-comers. At 7.07 a straggler came along and tried to get in. As the gate was nearly closed, she deliberately proceeded to break it open. A pebble was taken from the gate-covering and carried three inches up the mound. Another was tugged still farther up, and yet another. Then in steps the gate-closer, quite undisturbed by the counter-working of her fellow, and quietly plugs up the little break made with a big pebble, and slips within at a by-cranny that had escaped the straggler's notice.

A second straggler appears while the closers are adjusting the material from within, as may be seen by the agitation of the surface. Meanwhile the first straggler has grappled with the last big pellet dumped, which she succeeds in dragging aside—of which straggler number two takes advantage, and steps into the nest. Thereupon one of the closers reappears from the inside, and, without the least token of vexation at thwarted plans, restores the piece to its place and returns.

Straightway the first straggler renews her opposition effort, and has just set the pebble aside when a small black beetle comes up. This the straggler seizes, puts down, turns, reseizes, and tries to push into the gate therewith. The beetle, however, escapes; and the foraging instinct which led the straggler to forego for the nonce her house-breaking is not strong enough now to divert her from the home trail. So beetle goes her way unpursued and the contrarious straggler disappears inside.

At 7.20 a gate-closer comes out and adjusts several pebbles. My imperfect perceptions cannot discern the

advantage thereof, but doubtless the ant quite understands. The other closer is seen reaching up and adjusting pellets from within. At 7.21 the outside closer goes in at the small opening between the top of the gate and the inlying gravel. At 7.27 I still see, by the motion of the pellets of soil and agitation of the pebbles and occasional glimpse of the tips of antennæ and mandibles, that the final sealing-up of the communal walls is being accomplished within. In a moment all is quiet, and the gate of the emmet city is shut for the night. Externally it now seems to be a simple semicircular or triangular depression in the gravel armor of the mound.

The other illustration of the gate-closing habit among ants is drawn from the cutting ants (*Atta fervens*) of Texas, observed in 1877. [McC. 10, pp. 33–40.] One immense commune was assembled around the trunk of a live-oak tree (*Quercus virens*) on a road-side. The excavations from the interior had gathered into a mound twenty-one feet long and about four feet high. This accumulation, called by the natives a "bed," was evidently one of many years' standing, and when subsequently opened was found to be inhabited by legions of ants from the size of a bumblebee to that of a small garden ant. It seemed incredible that such hosts of living creatures could dwell within such a narrow compass and all find nourishment. And to think that they live on mushroom gardening!—as we shall presently see.

My first view of the mound was a disappointment. It was in broad daylight, and not a sign of life appeared. Could it be an abandoned nest? Having satisfied myself that the mound was inhabited, I arranged for an

evening visit. Here and there were scattered over the surface small, irregular heaps of dry leaves, bits of leaves, chips, and broken twigs, which seemed mere accidental drifts and piles (Fig. 41).

Returning about nightfall, I found the scene wholly changed. Hosts of ants of various sizes were already

Fig. 41—A CLOSED GATE OF CUTTING ANTS OF TEXAS

hurrying out of open gates into the neighboring jungle, and two long double columns were stretched from the bottom to the top of the overhanging tree. The ants in the descending columns carried above their heads portions of green leaves that waved to and fro, and glanced in our lanterns' light, giving them a weird seeming as they moved along. It is this habit that has given the insect the popular name of "parasol ant."

I first directed special attention to the opening and closing of the gates, which occurs before and after every exit. The opening began about dusk. First appeared from beneath the heaps of dry leaves and chippage scattered irregularly over the surface a number of minims, very tiny fellows indeed. They carried from within small grains of soil. Perhaps an interior cave may have been used as a dumping receptacle for the earth-pellets and smaller rubbish. This was a tedious process, and little seemed to be accomplished until this

squad was joined by larger forms, who began to carry away bits of chippage. This was also a slow process, but it seemed to avail in gradually loosening up the massy material crowded into the gate; for now came a grand rush from within, the workers, major and minor, and the big-headed soldiers in the lead. They broke forth, bearing before them the larger bits of gate-closing rubbish, which was scattered here and there, and in a few moments was cleared away from the gallery and strewed around the margin of the gate (Fig. 42).

This chippage appears to be a part of the communal treasure, for it was easy to identify a number of the pieces as having been used several days in succession. The ants having found out just what shapes and sizes

Fig. 42—CUTTING ANTS: A GATE WIDE OPEN

were best adapted for effective infilling, were wise enough to keep them close by and use them again and again.

The closing of gates began early in the morning and dragged along until ten o'clock. The galleries, of which the gates were the terminals, sloped from the surface, at as great an angle as forty-five degrees, a conformation

that favored the process of closing, as it gave purchase to the material.

In shutting the doors of the commune, the minors appear to begin work by dragging the dispersed chippage toward the gate. One after another they were taken in, and lodged and adjusted. It was certainly not a mere

Fig. 43—CUTTING ANTS: A GATE IN PROCESS OF CLOSING

anthropomorphic fancy that in this process the workers showed admirable ingenuity and a rude but effective sort of mechanical skill (Fig. 43). For example, the longest stalks and leaves were stretched across and wedged into the opening and vestibule so as to form a rough scaffolding upon which the shorter pieces could rest.

As the gate gradually filled up, smaller castes of workers appeared upon the field, and took up the work to which their slighter frames are adapted. The last touches were carefully and delicately made by the minims, who in small squads fill in the interstices with small pellets of soil. Finally, the last laborer steals in

behind some bit of leaf, and the gate is closed. The infilling material occupies the opening to a distance of (sometimes) an inch and a half within the gallery. The exterior of the gate now presents the appearance already described of a small heap of dry chippage accidentally accumulated upon the surface.

CHAPTER IV

SUPPLYING THE COMMUNAL RATIONS

FOR all living creatures food is a first demand of nature. The struggle to obtain it in the vegetable and animal kingdoms keeps the wheels of life in active motion; and day and night, secretly and openly, silently and with sound and stir of mighty conflict, it goes on among and around all beings. Its influence in shaping life and habit is constant and incalculably great. Indeed, in many, perhaps in most cases, it is decisive—at least in certain epochs of the individual and communal career. Thus, a study of the food supply of ants is of highest importance in determining their natural history.

As a general rule, covering most of our common ants, the founder of the future commune is a single fertilized female. After the marriage flight she seeks in the vicinage of her alightment a suitable site in the ground or in wood, according to her instinct. Therein she prepares a brooding-cell, which is commonly forced into an oval shape by her rotary movements in forming the wall that shuts her in. This cell becomes the tomb of the great majority of females, but a few survive to be the founders of communes.

The eggs laid by the queen are tended and the young are fed by her during her isolation, which may last three-quarters of a year. As she never leaves her hermitage, whence comes her food supply? Nature has

provided a store in the voluminous body, generously nurtured during her virginity by the laborious and self-denying workers of her home nest, who thus unconsciously had wrought out a further part in preserving their species. This stored-up substance, together with the degenerating wing muscles, is transmuted into food, which passes as a salivary secretion from the mother's mouth to the mouths of her progeny. In many cases this supply is supplemented by her own eggs, a considerable percentage of which she eats.

The first individuals matured are naturally scantily nourished, and for this reason, perhaps, appear as minims, or ants of the smallest caste. At all events, the firstlings are minims, and their smaller demand for food well accords with an empty larder. The known ability of worker ants to endure a long fast is shared to some extent by these callows. But as their philoprogenitive instinct at once awakes, and prompts them to feed and care for the larval dependents in the cell, the supply of rations is a pressing problem. Before the double demand of hunger and devotion to the commune, their primitive cell walls melt away, and the young ants break forth into a new world. What a great, strange world it must seem, even to their imperfect perceptions! Doubtless the first circles of adventure which these pioneers permit themselves have a short radius. That will be measured by their initial success in foraging; and that, in turn, will depend upon the site whereon it has been their hap to fall. In any case, their foraging journeys will sweep over an enlarging space, as the demands of their growing commune increase and their experience expands.

To a limited human vision the supply of available

edibles seems small. But to the omnivorous appetite of ants it is, under favorable conditions, practically inexhaustible. Ants have proverbially "a sweet tooth." In the vegetable kingdom, nature's vast fecundity of flowers and blossoms and sappy sweets, so far beyond what seems required for continuing the species, may seem a great waste. But to the insect world it presents a bountiful harvest. One sees them, of all the orders, winged and unwinged, as larvæ, as nymphs, as imagines, in countless hordes drawing upon this exhaustless store.

Among these insects, ants are everywhere most prominent; on the low-growing plants, close to mother earth, high up on the lofty trees, and in all grades between they peek and mouse. In companies, in bands, in ones and twos, their busy inquisition is pushed, and their restless antennæ wave and tremble. They dip into the flower-cups, and drink of the nectar there. They scout over leaves. They exploit the trunks and boughs. They are everywhere in Flora's beautiful domain, lapping her sweets, filling their crops with her treasures, growing rich from her redundancy, not for themselves alone, but for the helpless dependents of their communes. They jostle their winged kindred, the bees, the wasps, the hornets, the yellow-jackets, who come by the shorter aerial ways, but are fewer than the persistent and ubiquitous ants, who plod and climb by the roundabout routes which apterous beings must take. There is enough for all; and although I have seen thousands of these various forms feeding cheek by jowl upon some rare harvest feast of bountiful Flora's spreading, I recall no scenes of violence arising from the casual contact. Let the reader give no credit for this to the peaceful temper of the insects. Simply, it is hard to quarrel

when the crop is full, and when all may have who will all that they may will to have (Fig. 44).

It is pleasant to contemplate this phase of the latent helpfulness that lies in creation, and to see the inanimate world, the fields and forests, extending to the hosts of the Insecta so magnificent a hospitality. It is ill repaid,

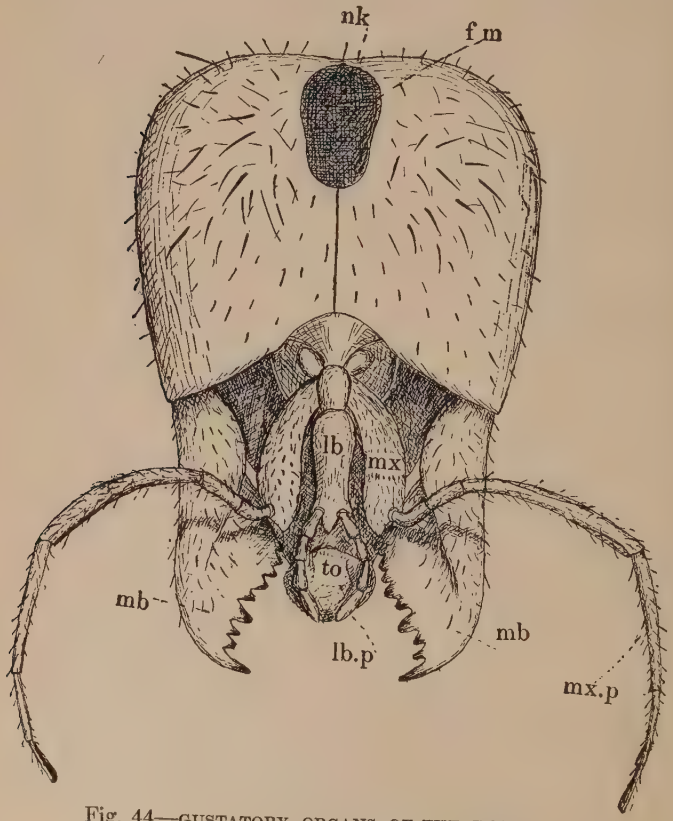


Fig. 44—GUSTATORY ORGANS OF THE HONEY-ANT

(Face viewed from beneath)

nk—Neck. *fm*—Foramen. *lb*—Labium. *mx*—Maxilla. *mx. p*—Maxillary palp. *mb*—Mandible. *to*—Tongue. *lb. p*—Labial palp

no doubt, at times—especially by the hordes that prey upon our gardens, orchards, and fields, and compel a ceaseless vigilance to save our crops. But, on the other hand, it is gratifying to reflect that Flora's bounty to ants and their insect allies is repaid by a service which preserves her domain by perpetuating the life of plants; for the insects that pass from flower to flower and plunge into the cups, distribute the fertilizing pollen upon which fruitfulness and life depend. This symbiosis between plants and insects is thus a necessary condition for both; and that it has existed from the beginning, a study of fossil insects shows.

The above seems, as indeed it is, a vast field wherefrom to cull a living. But one, perhaps as wide and even more lasting, is open in the waste products of nature. Ants are universal scavengers. They are fond of animal oils and juices. Countless millions of insects perish every season. What becomes of them? They drop by the waysides of their lives, and drift into all manner of crannies and corners. Hereto the ants follow them. The searching power of the antennæ is something marvellous. It has been compared to that of men's hands were the sense of smell to be located in the tips of all their fingers also, where such a delicate sense of touch abides. What human hands could do, in such a supposed case, to follow up and search out odors, the movable organs of smell, the antennæ, do actually accomplish for ants.

Thus are revealed to them the carcasses of the innumerable hosts of fallen insects; and often they may be seen headed for their homes, dragging with them whole bodies or parts thereof, and making painful headway therewith through the jungle of grasses and weeds.

Commonly, however, they are successful, when not waylaid and robbed by stronger individuals, or by roving bands of alien species, or congeners of other communes.

The fondness of ants for animal fats and juices may be tested by placing a fresh bone on the lawn or in a field. It will be covered soon with a crowd of emmets greedily lapping the oily particles upon the surface and exuding from the pores. Some housekeepers avail themselves of this appetite to collect groups of the little red ants (*Monomorium pharaonis*) that infest houses. These being destroyed, the "trap" is set again and again.

Another source of food supply is the various fruits in season, wild and cultivated. The windfalls lying beneath the trees and bushes are usually bruised, or stung by insects. Around and into these broken parts the ants gather and feast. They climb to the laden boughs. They scout among the ripening fruits. They have a quick touch for a spot of decay, which has opened a way for their gustatory attack. Or a bird's bill has been before them, cutting a little trough from which to sip the sweets they love, and herein one will see a bunch of ants scooping out the pulps and drinking their fill of the fermenting sap.

When September's sun has mellowed the grapes, you may see legions of ants, joint pilferers with birds and bees, hornets, wasps, yellow-jackets, and flies, many with heads buried deep within the berries. They are lovers of the new wine of the grape, and many empty or partly emptied skins, hanging among the broken clusters like cups drained of their contents, show how often and deeply they and their winged comrades have drunk. Doubtless ants are apt to be a bit injurious to our orchards and vineyards. But their share in the

general scavenger work of nature, as well as their part in fertilizing the blossoming plants, may be set to the credit side of their account. Besides, if folk would follow the author's rule to put in one root-stock for the birds and insects for every two set out for himself, there would be enough and to spare for all.

Preying upon insect remains and animal oils, lapping the nectar of flowers and the sweets of fruit, by no means exhaust the sources from which foraging ants may draw their rations. They are free-lances, and they do not scruple to ply their freebooting against all and sundry whom they are able to better in a quarrel over booty. After the manner of human cannibals, they feed upon their vanquished foes; indeed, the formal raids of slave-making ants are chiefly for food. Many thousands of their victims are carried home and eaten. The tender larvæ and pupæ are kept in store for the slaughter as human butchers keep live-stock and fowl, though one cannot aver that the ants deliberately fatten them for that purpose. Some captives, and at times a number, escape the shambles and become auxiliaries or slaves. But large communes of these kidnappers have been known to end an active season of slave-catching with but few if any increase in the number of slaves. All their captives had been eaten!

The same methods are quite commonly carried out on a smaller scale among various species. I have turned up a flat stone, beneath which was a large nest of small ants. Their larvæ, still smaller than themselves, lay in heaps against the under surface. Scarcely had the stone been lifted ere several larger ants, representing two other separate species, rushed in and began plundering the colony. They evidently had been prowling

around the confines of the nest, waiting for an opportunity to break through the barriers, or snook into some chance opening by which they could reach their desired prey. And this is a typical incident in ant world.

Other insects, both in the larval and imago state, are victims of this passion for hunting live game—as fierce and high as ever fired human devotees of the chase. Who has not seen an unfortunate caterpillar writhing in mortal agony beneath the assaults of a large squad of small ants? In vain the victim struggles to throw off its assailants. Its fate is sealed. Spurred into violent contortions by the smarting thrusts of stings and cuts of mandibles, it flings its tormenters to this side and that. They hold on grimly amid all the thrashings until the quiet of death gradually falls. Then the great carcass is dragged and pushed home by a gang of workers or carried thither piecemeal, a vast addition to the communal larder.

While studying the agricultural ants in Texas, I observed, after a summer shower, a great commotion upon a large circular disk of one of the colonies. The rain had beaten down a great number of the winged forms of swarming termites, and upon these the red agriculturals were charging from all parts of the plaza. They seized them in their jaws and ran toward the central gate, out of which a file of their fellows was eagerly streaming, intent upon sharing the rare find of booty. The outgoing and incoming columns met. The gate was soon choked up. The tiny rivulets caused by the rain were setting in the same direction, and presently a mass of excited insects was balled and matted around the gate, pushing and tumbling over one another, and splashing in the water. But the possessors of

captives from the fallen swarm held to their prizes amid all the tumult, until the jam was relieved, and they could get entrance within their nest. Their underground granaries were at the time full of stored ant-rice and other seeds, their provision for winter food; but the eagerness with which they welcomed this chance supply of soft, juicy insect flesh showed that their granivorous habit had not weakened their insectivorous taste.

I have seen the mound-making ants of the Alleghanies make raids upon the workers of our northern species of termites (*Termes flavipes*), capturing and carrying them away with an eagerness that showed what precious morsels their soft, white bodies must be to the Formican appetite.

Here we may consider the vast food supply that lies in the product of certain seed-bearing grasses, the garnering and storing of which has led to the popular names of "agricultural," "farming," and "harvesting" ants.[1] The habit is especially developed in the genera Pogonomyrmex and Pheidole, which collect from the ground and from plants certain grain-like and nut-like

Fig. 45—AGRICULTURAL ANT FEEDING FROM A HICKORY-NUT KERNEL

seeds (Fig. 45). These they carry to their nests, and, after removing the husks, and deporting the latter

[1] See the author's *Nature's Craftsmen*, chap. vi.

from the nests, they store the kernels in large granaries excavated in the ground, where they are kept for food. It has been noticed that these seed-eating ants are marked by the presence of large-headed workers, whose unusual development of the muscles of head and jaws particularly fits them to crack and crush the seeds, so that from the meaty kernels may be rasped or squeezed the edible starchy or oily parts.

A remarkable example of the unexpected way in which Nature varies her methods of feeding her children is seen in habits of the Attidæ, the "parasol" or "leaf-cutting" ants. This popular name is due to their manner of sending out expeditions of workers, who cut from the leaves of certain trees and bushes small pieces which they bring into their nest to convert into food. These leaf-cutting excursions are striking sights to the novice, and are not apt to lose their interest even to familiars. The author's chief studies of *Atta fervens*[1] were made in the vicinity of Austin, Texas. [McC. 10, p. 33 sq.] Most of their nests were "beds" (as the natives called them), or spots of denuded surface in the flat open prairie, eight or nine feet long and of almost equal width. Over this barren space were thrown up twenty or thirty circular, semicircular, and s-shaped elevations of fresh earth pellets. The circular moundlets were about the size and form of a "pound-cake"-pan, or spittoon, the resemblance being emphasized by a round open entrance in the centre. All these had been naturally formed by the gradual accumulation of the

[1] I have used throughout this, the old and well-known name of this species, although Professor Wheeler has restored the yet older specific name of Buckley, by which it will doubtless be known hereafter.

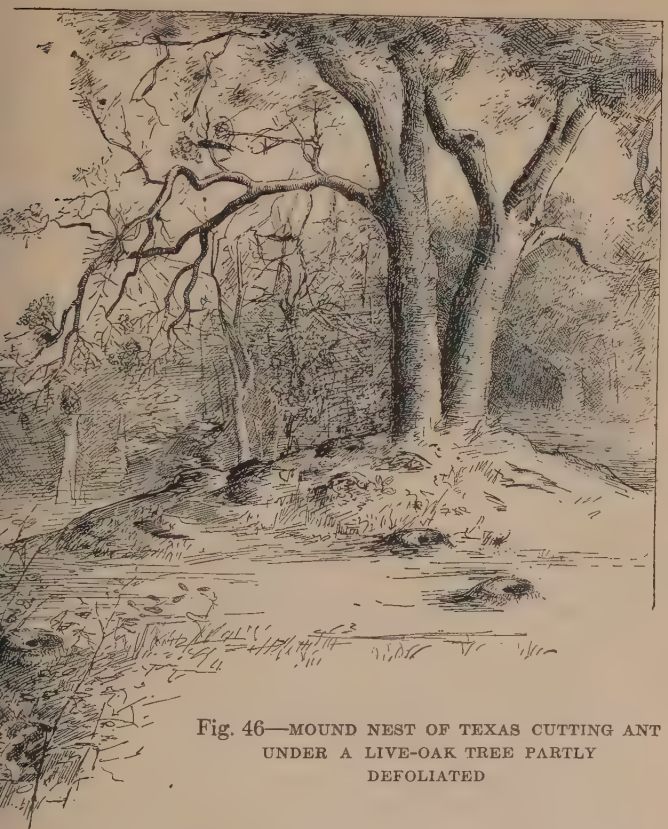


Fig. 46—MOUND NEST OF TEXAS CUTTING ANT UNDER A LIVE-OAK TREE PARTLY DEFOLIATED

ndy soil as it was brought out and dumped upon the eap, being massed at the base and gradually sloping the top. Another of these beds, the one which was pecially studied and finally opened, was a large mound the foot of a live-oak tree (Fig. 46). This had prob-ly been formed by a road or trail that passed with-several yards of the tree, thus restricting the limits the gates and throwing the separate moundlets back on one another. [McC. 6, p. 231.]

At my first visit to this great commune it seemed like an abandoned nest. On the spreading branches of the overshadowing tree and on the defoliated vines at its base were marks of recent raids of the leaf-cutters. But no life was anywhere visible. The surface was covered with earthen knobs or warts of various sizes, and here and there were scattered small irregular heaps of dry leaves and bits of leaves, and twigs. As evening began to fall the scene changed. Hosts of ants of various sizes, in countless numbers, suddenly burst from gates that mysteriously opened for them, and began a hurried march into a near-by jungle. Two large double columns began to ascend the trunk of the live oak. Along their flanks, both going and coming, moved the soldiers,

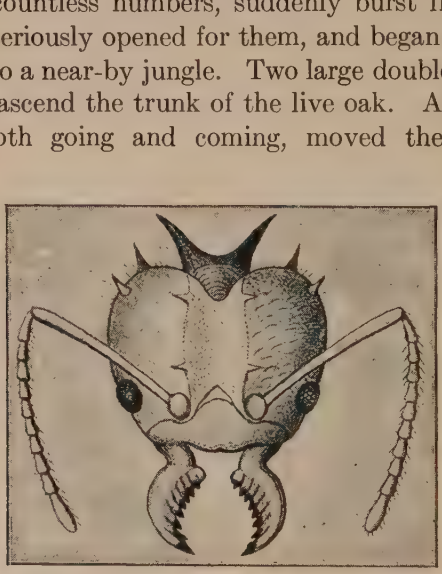
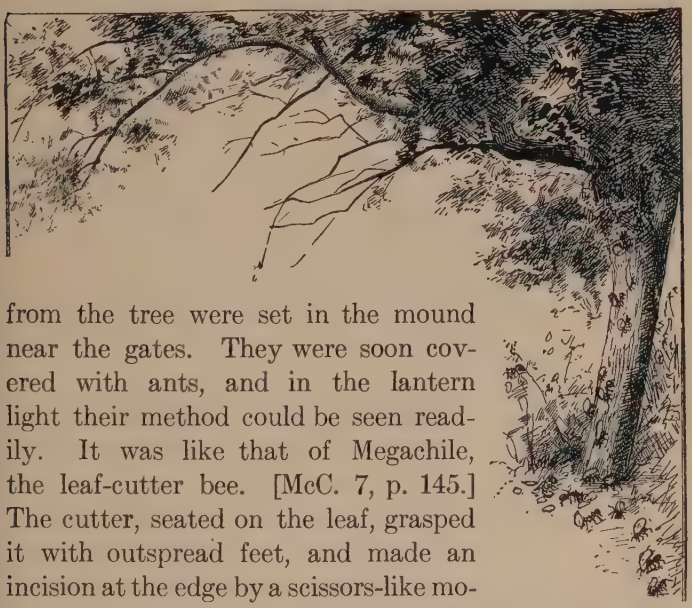


Fig. 47—THE HEAD OF A TEXAS CUTTING ANT
Enlarged eight times, to show furrow and spines and cutting jaws

marked by their immense heads (Fig. 47). They rarely handled the leaves, but seemed to act as scouts or pioneers or attendant guards.

In a few moments the two-ranked army had reached the top of the tree, and the work of defoliation began. In order to view the mode closely, small branches broken



from the tree were set in the mound near the gates. They were soon covered with ants, and in the lantern light their method could be seen readily. It was like that of Megachile, the leaf-cutter bee. [McC. 7, p. 145.] The cutter, seated on the leaf, grasped it with outspread feet, and made an incision at the edge by a scissors-like motion of her sickle-shaped and toothed mandibles. She gradually revolved, cutting as she moved, her mandibles thus describing a circle or a portion thereof. The feet turned with the head. The cut was a clean one, quite through the leaf. The

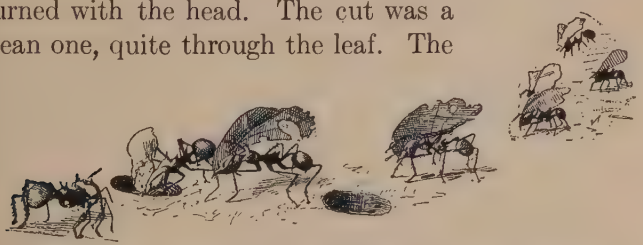


Fig. 48—A PROCESSION OF TEXAS ANTS CARRYING LEAVES TO THEIR CAVES

cutter would sometimes drop with the excision to the ground; sometimes it let the section fall; sometimes carried it down. At the foot of the tree lay a pile of cut leaves, to which clippings were being added continually by droppings from above. Squads of carriers from the nest took these up and bore them away (Fig. 48).

This is the manner of loading the cuttings: They are seized by the curved mandibles; the head is elevated; the piece is thrown back by a quick motion, and lodged on its edge within a deep furrow that runs along the entire median line of the face, except the clypeus, and is supported between prominent spines on the border of this furrow and on the prothorax. These peculiar features of the Attidæ thus serve a useful end. As far as noted, the cutting and carrying were not done by the minims or smallest castes, but by the worker-minors; the soldiers rarely engaged therein. As the ants moved along down the branches and trunk of the tree, and over the ground to their gates, holding above their heads the bits of green leaves, which waved to and fro and glanced in the lantern light, the column had a weird seeming.

The citizens of this commune, and of some others observed, made their leaf-cutting sallies in the night. But this is not the universal habit. I afterward saw carriers marching with their loads during the day. I also observed them frequently in day marches in the vicinity of Santiago de Cuba, during the Spanish-American war, carrying on their quaint industry among the graves of fallen American soldiers and in the tropical trees that sheltered them.

They were abundant on the great terraced height of the Morro, or castle, at the mouth of Santiago Bay, which I visited just after the surrender, and before it

was occupied by the American troops. When ascending the path that zigzags around the cliff to the summit, a column of these insects was seen marching with their bits of cut-off leaves. On the summit, workers were found close by the dismantled eastern battery. Their fresh-made tumuli were cast up almost beneath the butt of the great guns. The workers were thronging into the central gates, bearing aloft their leafy banners. One could not but wonder: Were these industrious creatures plying their task while Spanish cannons were firing and shells from American ships were bursting around them? No doubt they did so—a type of the army of industry in the insect world prosecuting the humble arts of peace amid the roar of human battle and the clash of arms. If their wee brains could be deemed capable of thinking on such matters, we may fancy their thoughts taking shape in the familiar words: "What fools these mortals be!"—maiming and killing one another when they might be comfortably cutting juicy leaves and chewing them into pulp!

At an afternoon visit to the grounds of a nurseryman and gardener near Austin, Texas, the leaf-cutters were seen at work. They had come up through the garden from their colony, three hundred feet distant. From this gentleman it was learned that these ants prefer trees with a smooth leaf; are severe upon grapes, peaches, and the china-tree. They take radishes, celery, beets, young corn, and wheat, plum, pomegranate, honeysuckle, cape jessamine, crape myrtle, and althea. They do not like lettuce, nor the paper mulberry, nor figs, nor cedar, except the bud ends in the scant days of winter. They love sugar, grain, and tobacco. This proprietor assured me that the ants made foraging excursions into

his house, entered his desk drawers, and carried away a portion of his chewing-tobacco before he discovered the robbery. He had to be careful thereafter where he put the delectable weed. At a plantation not far from this nursery I saw an immense column of Attas plundering a granary of wheat, which was being carried away in quantities, grain by grain. This pilfering was also carried on in the daytime. I have no explanation to give of this remarkable difference in habit in the same species, in the same locality, and apparently under the same conditions. Can *Atta fervens* have entered upon a transition period in its history?

How do the cutting ants dispose of all this material so laboriously imported into their underground city? Is it used, as with the cutting bee, simply to line the chamber or cells in which the young are reared? Let us see. It was no light undertaking to open and explore a mound occupied and defended by hundreds of thousands of irate ants. But it seemed necessary. Two trenches were made, one ten feet long and five feet deep, and a second at right angles to it wide enough to allow free entrance for study. The number of insects that swarmed to defend their home was incalculable. It amazed us to see such hordes of creatures domiciled in one commune. They were, however, not so difficult to manage as when disturbed at their night work, as the swift use of the spade by the assailants and the general convulsion of their emmet world seemed to daze them. But when the author entered the trench to work with trowel, knife, foot-rule, and drawing materials, the ants rallied and attacked so freely that all the helpers were required to brush them off. The wound inflicted by them was sharp, but nothing to compare

n painfulness with the sting of the agricultural ant
f Texas.

The interior of the great formicary (fifteen feet long, ight or nine feet wide, and four feet high; I do not

Fig. 49—CUTTING ANTS

1. Winged female. 2. Male. 3. Soldier. 4 Worker-major of the cutting or mushroom gardening ants.

now how deep, but certainly five and probably ten eet) may be briefly described as an irregular arrange- ient of caverns communicating with one another and ith the surface by tubular galleries. These caverns, or ockets, were of various sizes, three feet long and less y one foot deep and eight inches high and less. Within iese chambers were masses of a light, delicate leaf-

paper wrought into what may be called "combs." Some of the masses were in a single hemisphere, filling the central part of the cave. Others were arranged along the floor in columnar masses two and a half inches high, in contact with one another. Some of these columns hung like a rude honeycomb, or wasp's nest, from roots that interlaced the cave. No leaves were intact; none used, like the leaf-cutter bee, for lining wall or floor (Fig. 50).

In color this material was either of a gray tint or a leaf-brown. It was all evidently composed in great part of the fibre of leaves which had been reduced to this

Fig. 50—SECTIONAL VIEW OF A CUTTING ANTS' NEST
Showing mushroom garden caves in sight. (From nature)

form within the nest, doubtless by the joint action of the mandibles and salivary glands. On examination the mass proved to be composed of cells of various sizes, an irregular hexagon in shape, narrowing into a funnel-

like cylinder. Ants in great number, chiefly of the small castes, were found in these cells. In the first large cave opened there were also great numbers of larvæ. Large circular openings ran into the heart of the mass. The material was so fragile that it crumbled under even dainty handling, but some specimens were preserved and exhibited in the Philadelphia Academy of Natural Sciences. Thus the query was answered—in part, at least: What do the ants do with the leaf-cuttings carried into their nests?

But the most remarkable part of this history remains to be told.

While pursuing these investigations, the author knew that the suggestion had been made by Belt that the leaf-paper masses of Atta's nest were used as a sort of mushroom garden for cultivating a minute fungus which the ants used as food. Examination with a lens showed him the presence of these growths. But as this was only what might be expected in such underground conditions, and notwithstanding all that he knew of the ingenuity of ants in providing for the natural wants of their communes, he put aside the theory as improbable, and failed to push experiments which he might have made. His incredulity thus lost him the opportunity to anticipate—in part, at least—some of the brilliant discoveries of such later investigators as Möller, Von Ihering, Doctor Goeldi, and Jakob Huber. Briefly summarized, these discoveries are as follows:

In the case of *Atta sexdens* (the Brazilian cutting ant), after her marriage flight the fertilized female begins to dig in some open space a burrow about three-fourths of an inch in diameter. It is at first so small relatively that she cannot turn around in it, but has to back out

in order to get to the surface. But gradually the burrow grows as the queen cuts off and squeezes together little balls of earth, which are deported beyond the entrance.

When the terminal chamber is finished, the tubular entrance is sealed up. Later a little packet of eggs is laid. Beside it appears a small heap of loose white substance which gradually enlarges until it reaches the form of the spherical or elongated masses of gray comb-like matter heretofore described. And now the transparent pyriform globules of fungus-hyphæ begin to bud out, which Möller has called "kohlrabi." On

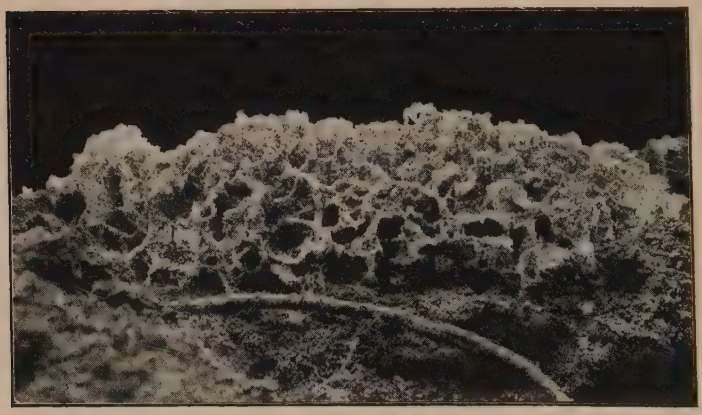


Fig. 51—A PIECE OF LEAF-PULP WHICH FORMS THE MUSHROOM GARDEN (After Möller)

these the ant feeds frequently. In truth, this is her fungus garden. It becomes in time the source of her food, just as an artificial mushroom cave or cellar produces nourishment for men (Fig. 51).

In time the first workers are hatched, and they too are fed upon the kohlrabi. As they increase in number

they break the cavern seals and go forth to gather leaves, which they chew and knead into pulp, and add to the fungus garden. And this is the purpose of those leaf-cutting expeditions which have enlisted the curiosity of casual observers, and excited the ardent and attentive study of many naturalists. They are to supply substance for the fungus gardens from which Attid ants glean food for their young and themselves.

Before this strange form of plant culture has reached this advanced stage, however, Huber introduces us to a remarkable observation, in answer to his query: How does the Atta female keep the fungus alive? For, plainly, the scant substance in the mother pellet must soon be drained of its original nutriment. How, then, are the growing fungi fed? The queen tears with her mandibles from her little bed a minute bit of the fungus, and applies it to the tip of her gaster, which is bent under for the purpose. She then emits a clear yellowish or brownish droplet, which is at once taken up by the spongy tuft of hyphæ. Thereupon it is returned to the garden patch, and patted into place with the forefeet. This performance may be repeated once or twice an hour or oftener, and several of the enriching droplets may be seen at once scattered over the bed. If a piece of the fungus growth from a maturer nest be supplied to an Atta female at this stage, she is prompt to appreciate and utilize the gift. She divides it, drenches it with her fecal droplet, and builds it into her garden. Meanwhile the mother feeds largely upon her own eggs, and when the first larvæ appear feeds them also with eggs, pressing them directly into the little creatures' mouths.

Soon the first adults begin to appear, which are always minims, or workers of the smallest caste. This intro-

duces a new order into the commune. They take charge of the garden; they feed the larvæ; they feed upon the kohlrabi; they begin to enlarge the central chamber, and in seven weeks after the founding of the colony they are out in the open dumping their earth-pellets upon their circular moundlets, and ere long the colony is sending out its leaf-cutting excursions.

Thus we see ant communes, under the exigency of the need of food, developing the habit of what has not inaptly been called mushroom gardening. They have mastered the method of liquid manuring, and of inoculating exhausted "soil" with an infected culture. They have learned the value of triturated vegetable matter as furnishing substance and enrichment for their gardens, and apparently they have found out that for this purpose certain plants are more valuable than others.

If such a principle—or practice—of plant culture were to be as generally and as faithfully applied to gardening and farming among men, it would need no prophet to predict that a new era would dawn upon the agricultural world, and such abundance would follow as our race has never witnessed.

Now very naturally arose the inquiry: Whence did the Atta queen obtain the fungus germs with which to stock the original garden? This was solved by Von Ihering in the brilliant discovery that on leaving the parental nest the young queen carries with her in the posterior portion of her oral cavity a very minute pellet of hyphæ of *Rozites gongylophora*, and small fragments of bleached or chlorophylless leaves. This, it is believed, is held in the mouth until she has prepared her foundation chamber, when she ejects it, and infects therewith the beginning of her fungus garden.

Thus the sober and well-attested facts of scientific truth prove stranger than the widest stretch of fancy would have dared to invent. Even in the face of unimpeachable testimony, one finds one's self startled and wellnigh staggering before such a remarkable instinct in an insignificant insect.

In the summer of 1880 my attention was called by the Rev. George K. Morris to a small ant which he had discovered at Island Heights, a seaside settlement on Toms River, New Jersey. I recognized it as a species of Atta which I believed to be new, and gave it the specific name of *Septentrionalis*.[1]

I was so strongly impressed by the appearance of this tropical species so far north that I at once visited Island Heights to study the insect in site. I found that the ants harvested the needle-like leaves of the pine, which were borne into their nests and treated in a way quite like that observed by the Texas Atta, but on a greatly reduced scale. The nests examined were without an exterior mound. A single gate communicated with a short tubular gallery with a small spherical vestibule, which again opened into a similar but larger cave three inches in diameter. Hanging to the roots that threaded this cave were several masses of gray leaf-pulp, the analogues of those in the fungus gardens of *Atta fervens*. As one contrasted the extensive excavations and the formidable and vigorous communes of the Texas species with the small numbers, slight excavations, and sluggish movements of these Northern allies, he could not forbear the thought that the New Jersey colonies of *Trachymyrmex septentrionalis* are the feeble remnant of

[1] Professor Wheeler has placed it in the genus Trachymyrmex (*T. septentrionalis* McCook).

a once mighty people left or thrust by some untoward change upon unfavorable sites which must work toward their extinction. [McC. 15, p. 360.] Or, on the other hand, may we conjecture that here are the first stages in the origin of a new species already on the march, and against unfavorable environment, toward the consummation of such a splendid confederacy as has occupied the hills of Austin?

CHAPTER V

FEEDING THE COMMUNE

CONTINUING our studies of the emmet modes of feeding the commune, our thoughts once more return to the great confederacy of mound-making ants among the Alleghany Mountains. We fix our attention upon a column of workers pressing along a well-worn path straight from a large mound to an oak-tree that stands by a boundary stone wall eight rods distant. There the column leaves the ground, mounts the trunk, and is lost among the branches.

But here several interesting things are noted. There is a descending as well as an ascending column. Moreover, there is something like the sentry service established at the gates. There is a tree-trail one to three inches wide, to which the ants steadily keep, and which is blackened by the continuous fumes of formic acid issuing from them. On either side of this are watchmen, who persistently challenge passers-by. There follow swift crossings of antennæ and mutual recognitions—how one longs to know the countersign!—prompt withdrawals, and the pilgrims pass on and are soon distributed among the principal limbs. A goodly number lead off upon one of the lower boughs which overhangs the stone fence.

Mounting this, one has the key to the movements of the marchers on the avenue beneath. At various points

along the branches are vast numbers of aphides, small black insects with brownish thorax and head. Note this one, whose abdomen is raised at an angle of forty-five degrees. Upon the apex is shining a tiny globule of transparent liquid. It is lapped up by the attendant ant, who all the while with alternate strokes of antennæ gently embraces or pats the insect. Again and again in rapid succession the sweet excretion, pumped by the insect from the sap of the tree, and converted by it into the honey-dew of popular speech, gathers in droplets, and is removed by the ants, several of whom have enjoyed the refection in turn.

At last the aphis, one of mature size, leaves its position and moves along the branch toward the trunk. Its abdomen is now flattened. Many of its fellows have that organ full and rounded out, and must be uncomfortable. The ants, however, are fast relieving them as the sweet excretion flows, and in the mean time their own abdomens are undergoing a noticeable change. They swell and elongate until the folded membranous bands that unite the segments are pushed out into narrow white ribbons. This is caused by the rapidly expanding crop into which the collected sweets are stored. At last the honey-dew gatherer, whom we may now call a "replete," is satisfied, and turns toward home. It is such as she that compose the descending column of ants upon the tree-trail; and their full, elongated abdomens and white bands form quite a contrast with the round black abdomens of their fellows of the ascending column.

We are now on the verge of one of the most interesting facts in the history of this remarkable community. These repletes belong to a section of the communal foragers, of whom thousands are elsewhere abroad, not

simply feeding, but collecting food supplies which they are taking home in their mandibles or stored in their capacious crops for the natural dependents and others of the formicary entitled thereto. Following with closer attention the trail of the repletes, you observe some of them suddenly disappear at the roots of the tree. Turn back the sod, clear away the leaves; what do you see?

Masses of insects are huddled together in the angles of roots at the foot of the tree and in sundry depressions in the soil. Some are repletes, some are ordinary workers; and the latter are stopping or trying to stop the former, who seek to avoid them and to push into certain openings that lead into galleries beneath the surface, which evidently communicate with the central mound. A few succeed in this, but many yield to the friendly force and halt.

And now what? See this replete. She has raised herself upon her two pairs of hind legs until her body slants in a wide angle toward the horizon. And one, two—yes, three workers, assuming a like rampant position, have placed their mouths against the replete's mouth. Look closely now, and you will see a droplet of amber or whitish, syrup-like liquid gather upon the delicate, thread-like maxillæ beneath the replete's jaw. It is the honey-dew obtained from the aphides upon the oak. It has been forced up from the crop by pressure of the contracting muscular sac that encloses it—in other words, by regurgitation. It is greedily lapped by the three "pensioners," and the replete breaks away and disappears within one of the gallery doors. All around the foot of the tree are like scenes wrought—visiting ants taking toll of the foragers.[1]

[1] In connection with these facts, see *Nature's Craftsmen*, chap. iii.

Who are these visiting ants? Are they highway robbers? They are certainly not aliens, for the relations of all concerned are most friendly. There is, indeed, here and there a slight show of force in the detention of a replete who has more than usual reluctance to part with its stored sweets, but there is no element of real hostility therein. Plainly repletes and pensioners are citizens of one community, and their behavior must form a part of a natural social arrangement. What is it?

Not all at once, but gradually, the facts dawned that repletes, acting as communal foragers, were carrying supplies to the formicary; that numbers of their fellows, engaged as builders, sentinels, and nurses, had left their several duties for a little while to feed, and instead of spending time and energy due to the commonwealth in gathering food afield, had come out to tap the garnered stores of their comrades, and, having relieved their hunger, would return to their labors. In short, they had been drawing rations from a sort of field commissary department. They are no devotees, these adventurers, of the theory that,

> "To feed were best at home;
> But thence, the sauce is ceremony;
> Meeting were bare without it."

There certainly seemed to be scant ceremony in this method of banqueting abroad. In truth, it had the outward look of levying mail or highway robbery, although there was no real violence on the part of those who bade the repletes "stand and deliver." Indeed, upon due reflection, the affair resolved itself into a beneficent social function, of which the following appears to be the spirit and intent: The ants at work in or about

the home premises leave the collecting of food to others of their fellow-citizens, not only for the public dependents but for themselves. Content with satisfying the simple wants of nature that they may have strength to toil, they leave their work and visit the feeding-grounds to get food from the repletes. The stations for this purpose are wisely chosen; for, as many of the foragers are overladen, their progress homeward is eased by yielding somewhat from their stores.

Besides, it seems probable that the instinct which urges repletes to gather supplies for home dependents might, after the formicary had been reached, prevent parting with them to others. Moreover, since ant nature in some degree is partaker of the weakness of human nature, it is supposable that the surplus honey-dew, after feeding dependents, would be kept for individual delectation, and the home working-force be compelled to leave their work and forage for themselves. The general movement, therefore, to arrest repletes at stations near the feeding-grounds is evidently for the public good.

It would be an odd speculation to consider the effect upon society were such a rule to prevail among men. Suppose the citizens of cities like New York, Philadelphia, and Chicago, or of such states as Georgia, Ohio, and Massachusetts, were to agree that one moiety of their number should take the duty of earning or collecting food supplies of every kind for the entire community, leaving all other duties to the rest? Further, suppose that these gatherings must be divided with equal hand among all sorts and conditions of people—young and old, active and dependent, high and lowly, rich and poor, with sole regard to their real natural needs?

Stop! Our phrasing is faulty; for in this ideal state

of society, if fairly conformed to the type of an ant city, there would be no rank or grade, no rich or poor, no personal distinctions, no individual property. All things would be in common. There would be one and only one property-holder—the State; nor would even the faintest desire for separate possessions ever cross the thought of the most fanciful. There would be no lust for riches or superior place or an easier lot in life. One purpose would dominate all with absolute sway: to serve the All—the whole community—with all one's powers, in any line of required duty, without hesitation, without stint, without reserve, and without pay.

This is truly a wild speculation! This is to conceive of the inconceivable—that human beings could attain the social standards of an ant-hill! One must first suppose a moral revolution which even the dreams of a Golden Age or a Millennium—such as idealists in every century have had—would dimly depict; a revolution more radical than that implied by a literal conformity to the precepts of the Sermon on the Mount and the Saviour's summary of the moral law. It would be a revolution not only in social characteristics, but in individual character, a veritable palengenesis of every member of the commonwealth. Would it be for the better or the worse? Would our race gain or lose by achieving the communistic-individualistic type of the government of ant cities?

It is evident that there must be a good deal of variation in the food supply even under favorable conditions. This would be felt at times when other labors of the commune, as extension and repair of the living quarters, interfere with the regular foraging. Moreover, there

are periods when the reproduction of eggs by the queen is especially active, and the vast increase of larvæ, all needing food and care, greatly multiplies the demand both for food and labor. The pinch of such conditions must fall inevitably upon the helpless young. Should they chance to come contemporaneously with a few days of scarcity, which may arise from various causes, the communal dependents must certainly fare ill, and the death-rate be enlarged among them.

And it befalls communes of ants, as it comes to nations of men, that great deviations from the ordinary course of nature bring about disasters, at times so great that the very life of the community is at stake. Famine follows in the wake of war and floods, and untimely frosts and droughts consume the sources of food in the world of ants even as of men. The plough turns up the fallow field, and multitudes of ant-nests are destroyed by agriculture. Thus some of our noblest species of native ants are vanishing before the advance of man, as are higher types of animals.

However, the vitality of some species under the strain of famine is remarkable. Miss Fielde has shown (*Tenacity of Life in Ants*) that the workers of *Camponotus americanus* may live nine months without food. They thus rival, in their ability to endure a prolonged fast, the queens that go solitary and draw upon their reserve tissue enough for self-sustenance and also to nourish the firstlings of their flock. The common mode of feeding the young, as heretofore described, is by transfer from the nurses' crops by regurgitation. But a wholly different manner has been observed that is more like our way of giving food to domestic fowl and animals. This grows out of the fact that the larvæ of

Pachycondyla and some other genera are able to feed themselves; perhaps have been educated thereto, though the natural aptitude must have underlain the habit. While lying upon their backs the larvæ suck the juices of particles of food given them. The nurses of Leptogenys dismember termite nymphs and scatter the pieces among their larvæ, who thrust their beaks into the soft parts and feed thereon. So also workers of Odontomachus will tear off the heads and legs of house flies, cut the thorax and abdomen into pieces and feed them to their larvæ. In the above cases the food was not first masticated, as is done by social wasps, but simply cut into pieces to expose the soft parts to the larval mandibles. Adlerz has made like observations of the larvæ of Leptothorax, Stenamma, and Pheidole, who are fed with solid as well as liquid food. [Quoted W. 11, p. 709.] Such increase in the variety of food and feeding the young must add to the chances of their wholesome survival by lessening the danger of a failure of food, since it greatly widens the field from which available supplies may be gathered.

An example of the strange exigencies that befall the inhabitants of an ant commune appears in the case of certain workers of *Pheidole commutata* that become infested with large internal parasites, and are therefore known as Mermithergates. This condition is accompanied with an enormous appetite, and they continually beset the nurses for food, which they get often at the expense of the hungry larvæ.

The voracious creatures not only ply the nurses with mimetic entreaties, including the out-thrust tongue, but keep up a stridulating chant of solicitation. At times they resort to more vigorous measures, and

seizing a replete, hold down its head with their large forefeet, and compel it to give up the contents of its crop. This greediness has its penalty in times when food is scarce; for in order to rid the commune of such voracious and non-productive mendicants, they are killed outright or starved to death by the workers.

The honey-ants as studied by the author in Colorado made their night expeditions into a scrub-oak copse, and the sweet liquid with which their crops were filled on their return was collected from oak-galls formed upon the twigs and branches[1] (Fig. 52). But, doubtless, like other

Fig. 52—SPRIG OF DWARF-OAK (QUERCUS UNDULATOR), WITH GALLS EXUDING DROPS OF SWEET SAP

ants, they know the value of aphides, and, as the seasons change, gather from them and from other sources the

[1] *Nature's Craftsmen*, chap. x.

supplies for current sustenance, as well as for their peculiar mode of providing for future wants. [McC. v, p. 17 *sq.*]

Among the honey-ants the workers, though varying in size, are structurally alike (Fig. 53). Yet certain individuals, quite independent of caste, and following an impulse unknown, but apparently fixed in the germ and

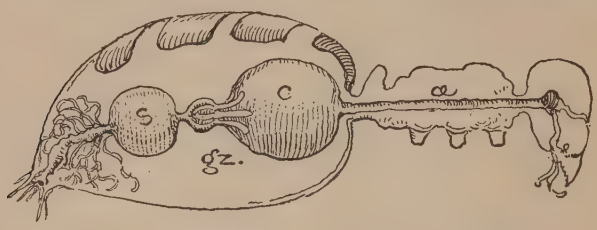


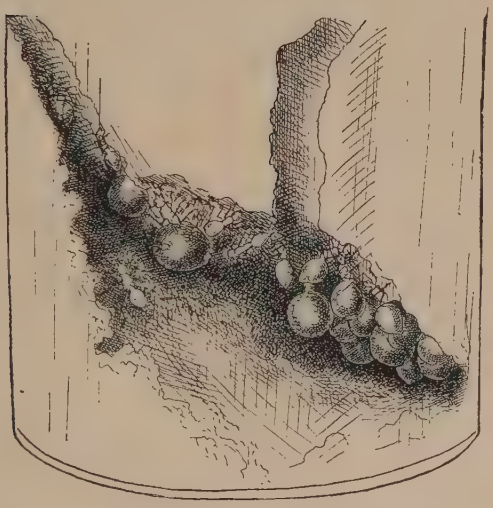
Fig. 53—THE DIGESTIVE TRACT OF A HONEY-ANT

Showing asophagus, *a*, as a nearly straight tube from the mouth to the abdomen. *c*—Crop. *gz*—Gizzard. *s*—Stomach

early manifest in the callows, begin to store up food in their crops, and thus develop into rotunds or honey-bearers (Fig. 54). It must be allowed to be a curious manifestation of communal philomyrmicry which causes one of the most active of creatures to become little more than an animated honey-pot, that the food supply of its fellow-formicans may not lapse. But so we find it; and, after all, it is little more than a development to its climax of an instinct that urges ants of other species to charge their crops with an excess of food in order to impart it to the commune dependents.

The insectivorous habit of ants has been utilized as a check upon the increase of certain destructive caterpillars. The author's attention was called to an article on the "Utilization of Ants as Grub-Destroyers in China," by Doctor Magowan, of Wenchow, and this led him to con-

a



b

Fig. 54—Honey-bearers or rotunds (*a*) in situ in a natural nest. *b*—Same with workers in an artificial formicary

sider at some length whether and how far those insects could be used in the United States.[1] [McC. 8, p. 263.]

[1] The information was received from a copy of the *North China Herald* of April 4, 1882, sent me by the Rev. Dr. Hunter Corbett, a Presbyterian missionary at Chefoo, China.

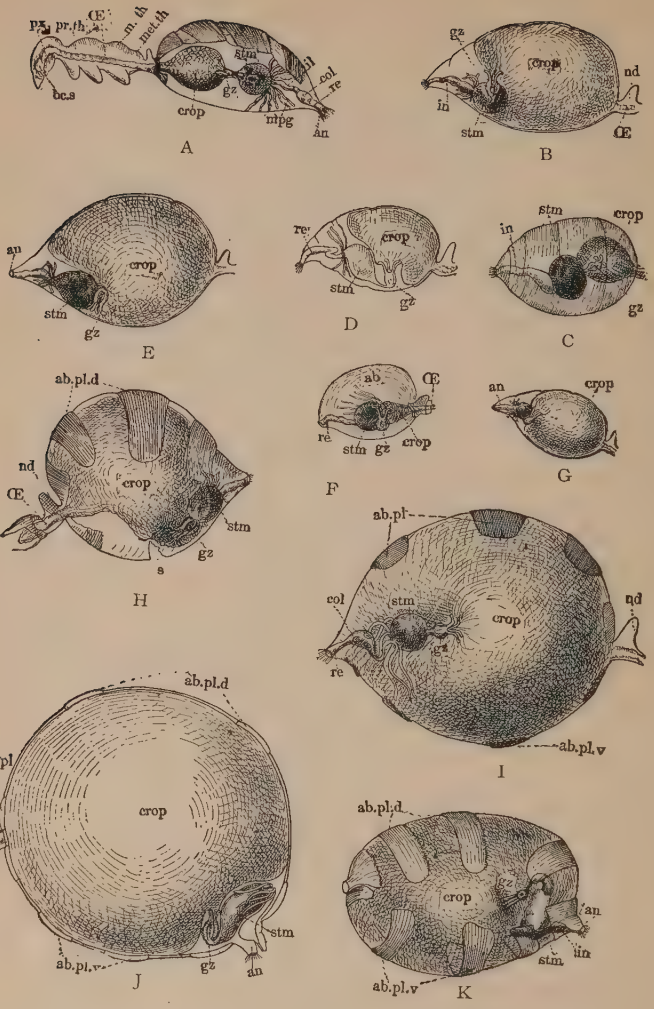


Fig. 55—ABDOMENS OF HONEY-ANTS

Showing the progressive development of the crop in various worker forms—from the worker-minor to the honey-bearer

See footnote page 113

According to Dr. Hunter Corbett, in many parts of the province of Canton, where cereals cannot be cultivated profitably, the land is given up to orange-trees. These are subject to attack by a species of "worms"—the specific name is not given—which work serious injury in the orange orchards. A peculiar mode of protection from these enemies is adopted by the proprietors, apparently suggested by the fact that the injurious larvæ are preyed upon by certain ants native to the orangeries. But these are not bred in sufficient numbers to be of much practical advantage. Resort was therefore had to the "hill-people" of the countries, who find the ant nests suspended from the branches of the bamboo and

A. Synthetic figure exhibiting the entire course of the alimentary canal in ants.

B to *J* compose a series illustrating the progressive distention of the crop from its normal condition to that of the honey-bearer.

In *C* and *F* the crop is normal.

In *B* and *E* (workers-major or semi-rotunds) the distention is well advanced. In *F* the crop has shrunk after distention. *G* shows the same process in the abdomen of a worker-minor.

H. Abdomen of a honey-bearer, opened at a slit (s), to puncture the crop, and show by its shrinking that it had filled the abdominal cavity. *I* shows the full crop of a honey-bearer with the lower part of the alimentary canal shown through the abdominal wall against which it is pressed.

J is the abdomen of a honey-bearer, wherein the full crop has pressed the gizzard, stomach, etc., into the cloacal cavity. *I* and *J* were apparently in normal health.

K is an abdomen of *Camponotus inflatus*, the Australian carpenter ant, which exhibits the characteristic distention of *M. hortideorum*. Drawn from alcoholic specimen. Other specimens are quite spherical.

Key to lettering, uniform in all figures: *ab*, abdomen; *ab pl d*, abdominal plate dorsal; *ab pl v*, abdominal plate ventral; *an*, anus; *bc*, buccal or mouth sac; *col*, colon; *gz*, gizzard; *il*, ileum; *in*, intestine; *m th*, mesothorax; *met th*, metothorax; *mpg*, malpighian tubes; *nd*, node; *œ*, œsophagus; *pr th*, prothorax; *px*, pharynx; *re*, rectum; *stm*, stomach.

other trees. There are two varieties, a red and a yellow, whose nests resemble small cotton bags. These are captured by the Chinese mountaineers by means of pig or goat bladders baited inside with lard. The mouths of the bladders are stretched across the gates of the ant-nests, and as the insects are fond of oils and greasy food, they enter in, are trapped in great numbers, and are sold at the orangeries. They are colonized upon the trees by turning them loose upon the branches. Once established, they begin their work as insecticides by capturing and killing the destructive larvæ. To enable them to pass freely from tree to tree, all the trees of an orchard are connected by bamboo rods.

Whether such a method is practicable in the United States, at least to an extent to justify extensive use, may be doubted. If successful at all, it would probably need the painstaking patience of Chinese men with the Chinese ants. However, a somewhat similar experiment has been tried upon a Ponerine ant (*Ectatomma tuberculatum*), popularly known as the "Kelep." This ant was imported into Texas by the United States Department of Agriculture as an insecticide, with the special purpose of directing its insect-destroying energies against the cotton boll-weevil. It had shown marked tendencies in that direction in its native Guatemala. Apart from the more or less complete success of such experiments, the fact remains, which is here relevant, that it is one of a great army of ants that feed upon living insects.

That this habit is widely distributed among the native ants of our Southern States was shown in a report made by the author [McC. 9, p. 182] a number of years ago to the then entomologist of the Department of Agri-

culture, Prof. J. H. Comstock. Several species therein described were found to prey upon the eggs, the larvæ, and the pupæ of the cotton caterpillar over a wide section of our southern territory.

It is not difficult to suggest a theory as to how the taste for cereal foods may have arisen among ants. Whether it be the true one or not is another matter. Following their habit of general scouting for supplies, and of putting all promising objects to the test of antennal or gustatory approval, they would be sure to fall upon seeds in the milk stage. Being then soft and easily crushed, and to the ants a toothsome relish, all grain-like seeds would soon commend themselves, and easily pass into the accepted and fixed menu (Figs. 57 and 58).

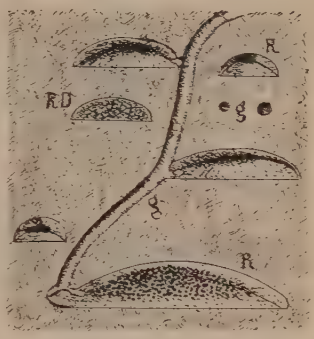


Fig. 56—SECTIONAL VIEW OF THE STOREROOMS OF THE OCCIDENT ANT

r—Seed-rooms. *rd*—Dumping-rooms for storing pebbles. *g*—Galleries.

As the outer shell gradually hardened, the growing taste for such food would prompt to break it open, and so would come, little by little, the habit of removing the husk. Although the flavor of the seed would change with its ripening, one readily conceives that the taste for it might have a corresponding gradual change: and also the power of utilizing it for food by rasping off or breaking up the starchy substance instead of crushing and lapping it, as in the milk stage.

In quite the same way the use of nutty or oily seeds

would gradually form, aided by the natural emmet appetite for animal and vegetable fats and oils of all sorts. The tendency to carry all these seeds to the common centre, the nest, would in due course be followed by, first, the taking off and deporting the useless husk or shell, and, next, the retaining for temporary, and so at last storing (Fig. 56) for more permanent use, the grain or nutty meat of the seed. The harvesting habit in ants since it was first scientifically confirmed by Moggridge [Mg. 1] has excited an exceptional degree of interest and sur-

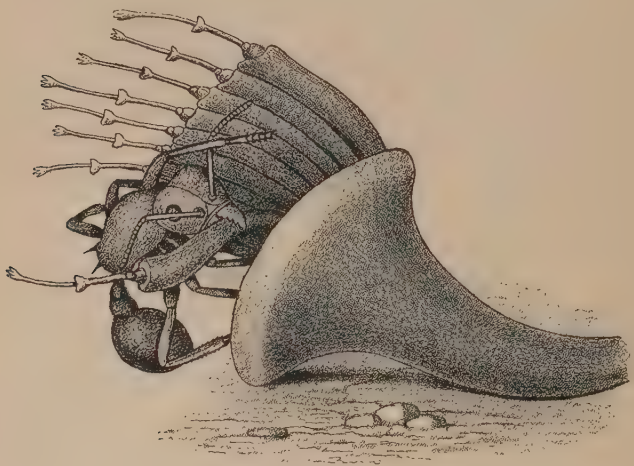


Fig. 57—OCCIDENT ANT HARVESTING SEEDS OF WILD SUNFLOWER

prise. But in truth, when one considers all the conditions, the wonder is that it is not more widely distributed.

Here we may notice a peculiarity that appears in the communes of a Texas species, *Pheidole instabilis*. A study of its feeding habits presents a striking example of a sharp distinction between the functions of the soldier and the worker caste. The workers are much

the smaller but far more numerous, and the bulk of the commune's work is done by them. They collect and store seeds and dead insects. They dig rooms and galleries, care for the huge royal larvæ and pupæ, feed the brood, and aid the callows break out from the pupal sac.

Fig. 58—POSTURES OF THE FLORIDA HARVESTER IN CUTTING SEEDS FROM THE STEM

The soldiers do none of this work. They are the communal trenchers. They crush and carve the tough insects and hard seeds stored by workers, a service for which their large muscular heads and jaws are well fitted. The same organs are efficient weapons for defence of the commune, a service which attaches to them as soldiers. As such they may be seen, as if on sentinel duty, surrounding the communal dependents. They are stolid in temperament. They decline, in Indian fashion, to take part in nursing the communal young. Their big heads, though of such value to the commune, may sometimes be a serious incumbrance to themselves; for when dropped upon their backs on a polished surface, they are not able to recover themselves, and may die literally standing on their heads.

It seems to be an odd characteristic that these megalacephalous creatures appear never to feed upon the oily seeds and insect juices which they make available by cracking the material brought in by the workers, but live on liquid food regurgitated by the workers.

One must note in this a beneficent arrangement; for the soldiers, not being exposed to the temptation of feeding directly upon the food which they carve for the workers, and which must thus all pass through their "hands," make sure that the dependents are not stinted or starved and the community thereby imperilled. This characteristic seems all the more important in view of the philoprogenitive defects of these soldiers. A species of Pheidole is found in and around Philadelphia, and it

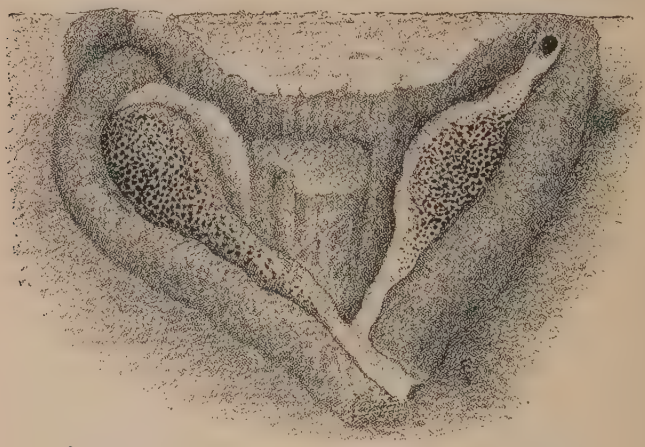


Fig. 59—SECTION PENNSYLVANIA HARVESTING ANT
Sectional cutting, showing storerooms, or granaries, in site, of the *Pheidole pennsylvanica*.

too is characterized by a big-headed worker caste. I have made observations of its seed-storing habits (Fig. 59), but it remains to be learned whether the soldiers have acquired so remarkable a rôle as that of communal trenchermen. [McC. 4, p. 148.]

Some of the feeding habits of the Indian Leptogenys are interesting. Writing of *Lobopolata distinguenda*, Mr. Wroughton says [Wr. 1, pp. 56–58] that it is occasion-

ally seen going about solitary, probably when acting as scout, but ordinarily is only met in the early morning or late in the afternoon travelling in an unbroken column four to six or eight abreast, by the straight or the easiest road to the scene of operations. This is usually a colony of termites, or white ants, whose galleries have been broken open by the hoof of a passing beast or some like accident. Apparently they do not have the initiative faculty of breaking into the termites' nest, but wait for an accidental opening. Arrived at their destination, every ant seizes her termite prey, swings it under her thorax in the usual way of these porters, and the attacking column then moves homeward. But the return formation is much less regular than the advance; it is, in fact, a "march at ease."

The same writer gives a note on the allied species *Lobopelta chinensis*. A populous community of this ant had settled in a cavity of the house foundations of Mr. Aitken, who reports the incident. From this nest there ran a well-marked ant road which crossed a broad gravel path and then branched out over the tennis-ground. After sunset the workers would come out and march along one of these branches, or break up into parties and take different routes. Their point of approach was a termite's nest; and when they reached a place where these insects had thrown up new earthworks, and were busy eating dead grass underneath, they collected in dense masses, awaiting an opportunity to break in. This came when the termites sought to extend their works on any side. Then the waiting columns of ants were precipitated in mass upon the unprotected creatures, and the slaughter began. Sometimes the termites were killed faster than they could be carried off.

After one raid, as late as 7 A.M., the ground was still heaped with the slain, and an unbroken stream of ants fifty-six yards long was taking them away, every porter having two or three of the dead in its jaws.

Sometimes the tables would be sharply turned upon the plunderers. If they chanced to cross the territory of a commune of harvesting ants after they had opened their gates and were abroad on morning duty, the Lobopelta hordes had to flee before their betters, often abandoning their booty. Yet, per contra, the observer once saw a Lobopelta, who had come to the aid of a comrade assaulted by a harvester, after vainly trying to tear off the aggressor, deliberately pick up both comrade and assailant, and carry them off together! Apparently both were so intent upon the personal combat that they gave no heed to the deportation.

Leptogenys elongata feeds largely upon the common wood slaters (Omiscus and Armadillidium), which abound under stones and logs in shady sites where the formicaries are placed. [W. 8, p. 253.] The workers have repeatedly been seen carrying dead slaters in their mandibles, and the space surrounding the gates is white with bleaching limbs and segments of the crustaceans, a proof that great numbers of these animals must be destroyed by the ants. Their long, toothless mandibles resemble scissors, and are well adapted for piercing the intersegmental membranes of their prey and exposing edible parts. This ant appears to be the only one known to feed on crustaceans as a regular diet. Other species are insectivorous, granivorous, mycetophagous (fungus eating) feeders on the sweet, liquid excretions and secretions of insects, or the juices and sugary exudations of fruits, plants, and galls, and on animal fats and oils.

CHAPTER VI

THE LANGUAGE OF ANTS AND OTHER INSECTS

LANGUAGE is essential to effective government among social creatures. Without means of communication of some sort, it would be impossible for societies to hold together and to act together in those communal movements which are alike the evidence and the end of social organizations. Thus we infer that some way of making known the common will and aim must exist among such insects as ants, bees, wasps, and termites that maintain permanent sodalities. And so we find it in ant communes. Thus is preserved unity and efficiency, by holding the citizens together; by disseminating purposes and influences important to civic success; and by securing at once mobility of action and the concentrated force of the republic, for peaceful service, for common defence, and for aggressive enterprise.

Men commonly think of language as a vocal medium for conveying thought and emotion from one individual to others. As thus defined, insects are dumb, for they have no true voice nor organs of speech such as belong to "articulate speaking men." They also lack the means of uttering such cries as characterize birds and brutes. But if we take language as simply an understandable medium for expressing emotions, insects are thus endowed. By certain movements of the body and of parts of the body, especially the wings, antennæ, and

jaws, and by sounds made by various organs in sundry ways, they convey to one another the primitive and simple emotions of their kind and of all animate beings. In taking up the subject as it bears upon ants, we shall best reach such conclusions as seem at present attainable by considering it in relation to insects in general.

The language of insects may be regarded as *mimetic*, when emotions are expressed by gestures or acts; *pteratic*, when by wing vibrations; *spiracular*, when made known by sounds issuing from the breathing tubes or spiracles; *stridulatory*, when conveyed by the friction of one organ against another; and *antennal*, when the antennæ, or "feelers," are the media of communication.

Insects express emotion mimetically—that is, by bodily gestures. Mimetic language, though more limited in its ability to convey ideas, is not less intelligible than vocal speech. Indeed, a glance of the eye, a movement of the hand, a shrug of the shoulder, a stamp of the foot, a toss of the head, may betray in man the true thought or feeling within him, even when spoken language is used to conceal it. How apt a medium mimetic language may become for expressing clearly a wide range of ideas one may see among the inmates of institutions for the deaf and dumb. We may find, perhaps, that this medium serves insects no less effectively for communication within that limited range—of *ideas*, shall we say?—to which their faculties are confined.

Let us stand before this oak-tree and watch a double stream of mound-making ants thronging up and passing down the well-marked trail that leads to a herd of aphides upon some oak-tree branches. The motion of a finger near the trunk attracts the attention of a sentinel, one of a number that seem to be guarding the flanks of

the column. It halts, thrusts out its antennæ, and shows signs of excitement. As an experiment, the finger is moved slowly within an inch or more of the ant. Its antennæ wave rapidly. Its head and body jerk with eager intentness. It stretches forth its head, and reaches out its fore legs, with jaws eagerly agape and antennæ quivering (Fig. 60). The whole attitude and every bodily detail clearly express to the observer the idea of vigilance, of suspicion, of a challenge, of a purpose to repel. As plainly as if it had spoken, the sentinel has said: "I suspect you! I test you! I bid you begone!" We onlookers understand this. Is it supposable that the ants themselves do not understand?

Fig. 60—MIMETIC LANGUAGE IN ANTS
The gesture of repulsion and defence

From the tree-path we turn to the conical mound

whence these ants are issuing. It stands silent in the shadow of the tall surrounding trees, its quietude broken only by the movements of a few worker-ants, who are lazily dumping pellets of soil from one of the few upper ports. At the base of the cone, where most of the gates are located, the column stretches across the grove to the aphis-covered oak. Give the mound a sharp blow with foot or hand. What a change! Instantly the whole community is aroused. From every gate pours forth a surging torrent of irate sentinels, followed by other inmates, until, in an incredibly brief time, the mound is covered with angry insects. They run to and fro, their bodies a-quiver as they go. They challenge one another with crossed antennæ. They peer at every unusual object in their way. They startle, and stand rampant at the vibration of every sharp sound. The surface fairly buzzes with the excited creaturelings, their whole mien and attitude saying, unmistakably: "Our home has been attacked! We are in danger! Rally to the defence! Death to our enemies!" (Fig. 61).

We change the field of observation. The writer was once standing before the great round web of a female Orange Argiope (*Argiope aurantium*), a large and handsome orbweaving spider [McC. 24, pp. 97, 98, vol. i], testing with a tuning-fork its sense of hearing, when a bee flew by in exploitation of a flowering honeysuckle vine that covered an arbor on which the web was hung. The droning of its wing-strokes as it flitted from flower to flower fell upon the ear as a token of content. To all and sundry it said, or seemed to say, what no doubt it felt: "I am a well-satisfied bee!"

But in a hapless moment it touched the spider's orb. Its feet were entangled in the sticky threads. Straight-

way its wings began to move violently, and their buzzing, together with the attitude of the body and of every member thereof, expressed the creature's fear. These varied as the bee became more thoroughly entangled,

Fig. 61—ANTS IN ATTITUDE OF COURAGE, ANGER, AND ALARM

now waxing, now waning, until the audible notes produced by its enfeebled movements seemed to utter its growing sense of danger and dread.

Meanwhile, and the interval was rarely brief, Madam Argiope underwent a striking change. She had been enjoying peacefully a dejeune of cold Diptera, taken through the fibres of a silken saclet in which her prey was encased, and which hung upon the upper part of the

oval rug that overlay her central seat. But instantly the bee struck the web her whole being was transformed. She dropped her lunch-bag. Her reposeful attitude was changed into one of eager animation and intense ferocity. Every spine and bristle upon her legs, her body armature, seemed to be erect, and her fangs were open. With a rush, like the vault of a cat upon a sparrow, she charged over her web, and, seizing the bee with her fore paws, shot forth upon it from her expanded spinnerets a band of silk. All the while revolving the insect between her swiftly moving fore feet, she soon had it swathed as closely as a mummy.

This done, her outward seeming of tense energy relaxed, and having suspended her empouched captive to a twisted strand of her broken snare, she left it hanging there, like a cured ham to the rafters of an old-fashioned smoke-house, and quietly resumed her interrupted luncheon on the fly. In all this, Argiope was without speech; yet her varying emotions were plainly and, one may conclude, not incorrectly, read by the observer from her motions. As for the bee, its last audible utterance was a low and broken hum that sounded like the expiring wail of apian despair.

Now entered upon this tragic scene of animated nature, man the philanthropist, his pity crossed, let it be confessed, with a strain of curiosity to know the condition of the prisoner. "Poor bee," quoth the observer, "this great and greedy spider has quite enough food without you!" With a pair of pocket-scissors an opening was made into the swathing-sac. Not without protest from Argiope, however, who, feeling these movements through the delicately strung meshes of her web, feared that her prey was escaping, and rushed upon it.

She was turned back by a smart tap upon the head; whereat she seized the tip of her rug and began to oscillate her snare, as though to shake off an intruder.

When this diversion had quieted down, the scissors were plied again. As the rent lengthened, the bee seemed to awake and began to stir. One leg appeared, then a wing. Thereupon issued a low hum of satisfaction, which rose into a higher note, apparently of vexation, as the body gradually appeared. At length, with a burst of limbs and wings, the insect was free. There was no mistaking the character of her emotions now; they were not jubilant. She was mad!—and was waxing madder in remembrance of the indignity put upon her. Her wings vibrated with a velocity that raised their responding sound to a high note which plainly signified wrath and vengeance. The observer, at least, understood; for instead of turning its wrath upon its captor, the bee made straightway for its liberator with sting outthrust, and with that peculiar buzz which bee-familiars know as a war-note.

Discretion—in that case "the better part of valor"—justified retreat. Moreover, the quest was not quite ended. It had been determined that an insect can be captured and swathed and trussed up by a spider without impairment of aught but her temper. But it remained to see what her beeship would do; and that soon appeared. Its pursuit of its back-stepping deliverer ended, it turned again to the honeysuckle vine, and took up its search for pollen and nectar as though life had known no "hairbreadth 'scapes" from deadly peril, and timely rescue therefrom. Her war-note died away into the old droning hum of peaceful industry and busy contentment.

Here we have a series of actions by which two invertebrates clearly communicated their emotions. The spider passed rapidly through stages reaching from quiet enjoyment of food to intense passion of the chase and ferocity in capture, and to the repose of success when the prey was secured. Thence the course swung to rearoused energies under apprehension of loss, and to fear of some unknown superior foe when rapped by the observer, and anxiety to defend herself therefrom, as shown by shaking her web.

The bee, too, had swift transitions: from her hum of contented industry to the subdued note of resignation to her fate when shut up in her silken sarcophagus; thence to vivid reawakening to life, with her sense of injury, her blind wrath and revenge, the wish to strike at something; and so back to where the cycle began: at the song of peaceful labor. In all these stages these children of the wild betrayed their current moods to man. "There was speech in their dumbness, language in their very gestures." No careful observer of their natural actions and of the field-life of their kind can doubt that, within limits indefinite and difficult to define, like actions among the more highly organized insects are understood by one another.

Still further, it does not seem probable that the ability thus to make known their emotions is limited to such modes of expression as human intelligence can interpret. Beyond the sphere of ideas and sentiments whose symbols men can discern, there doubtless are others peculiar to themselves, and therewith due methods of intercommunication.

In the cases above cited the actions may be said to have been simply the unconscious physical expression

of natural animal impulses, without any purpose to communicate the same to another, such as language implies. Even so, it should be considered, first, that these examples are given as types of other uses of mimetic language behind which lies the undoubted purpose to communicate. And, second, that the rude evolutionary germs of language in primitive man may have been the utterance of just such impulses; and little more need be claimed for insects. It marks the impassable difference between the psychic powers of man and those of insects that human language, spoken and written, has developed into its marvellous proportions, while the symbolism of insects, and of animals generally, retains the crudity of ancestral types, and apparently can never pass beyond this bar of nature.

There was something more in this typical living tableau of the spider and the bee than "gesture language"; for the wing movements of the bee, as we shall presently note, were special media of communication. But the language of natural bodily motions may claim some further attention here. If an unarmed man be threatened by his fellow, his almost unconscious mode of expressing his feelings will be to dodge or crouch or flee, if he be afraid; or if he be brave and his combativeness be aroused, to throw himself back upon one leg and put up his fists in self-defense. Under like conditions a bear will rise upon its hams and extend its fore paws, and a horse will rear upon his hind legs and strike out with the fore legs and hoofs.

It is a long step from the primate, the ungulate, and the ruminant to the invertebrate. But let us present similar conditions to certain spiders—say, the "tarantula" of the southwestern United States. It takes a rampant

position, resting upon its two pairs of hind legs, while its two front pairs, palps, and fangs are thrown up in striking posture. [McC. 24, vol. ii, p. 320.] The same attitude may be seen in the little jumping spiders (Attidæ) around our house walls and vines.

From the tarantula turn to the stream of agricultural ants of Texas, pouring over the roads that lead into their harvest fields. Fix your eye upon this worker, returning home carrying a grain of ant rice. Every motion of her body, which fairly palpitates as she hastens on, shows her sense of importance and satisfaction in service. Now tap her with your pencil-point. What a transition! She instantly stops, drops her burden, and rises rampant, the fore part of her erect person declaring unmistakably that she is startled, angry, and means to fight. She thus takes her place as a link in the chain of life leading down from man, among the creatures that communicate their belligerent mood and purpose by bodily attitude and gesture.

But something more than signals and gestures appealing to the eyes met the observer of that affair between the orbweaver and the bee among the honeysuckle blooms. The bee's wings made effective appeal to his ears, and by their varying vibrations gave a fair token of her tempers. This was "pteratic language." The droning among the flowers, the quivering amid the spider's meshes, the sharp buzzing of flight after release sounded in unmistakable notes the insect's amiability, anxiety, or anger. One can detect these varying notes as he walks his garden and field while the bees are foraging among the flowers or while one watches by his beehives. So, mayhap, Shakespeare did near by Anne Hathaway's door, or while treading the pathway across

the fields from Avon to her cottage gate, and saw the busy workers, like raiding soldiers,

> "Make boot upon the summer's velvet buds;
> The singing masons building roofs of gold."

Gardner, an English writer on the *Music of Nature* (1832), makes the curious statement that he was once in the gallery of the Royal Exchange to view the money-dealers in the court below. He was struck not only by the likeness of the scene to the interior of a beehive, but by the similarity of the sound, the buzz of the two thousand voices being perceptibly amalgamated into the "key of F." This is the key, the author concluded, to which the most prevalent sounds of nature may be referred—a fact by which musicians have unconsciously been influenced; for scarcely an ancient composition appears in any other key, except its relative minor, for the first hundred years of the art. In Queen Elizabeth's *Virginal Book* of four hundred folio pages nearly all the pieces are confined to this key. There is not an instance of a sharp being placed at the clef.[1]

According to the same author, the house-fly and the honey-bee hum in F on the first space. The bumble-bee, the contra-basso of the tribe, performs the same note, but an octave lower. The present writer is able to confirm this conclusion only in part. F seems to him to be a nearly true note for the common fly as tested by his ear, unaided by an instrument. But the wing-note of bees and the general tone of a large miscellaneous company of insects humming above a bed of flowers—hydrangeas, for example—seemed to him

[1] I have not the opportunity to verify this statement, which I make on Gardner's authority.

to be A, as tested by the flute as well as by the ear (Fig. 62).

Recently the vibration of insects' wings—their pteratic language—has been studied from the character of the note caused thereby, the pitch determining the

Fig. 62—PTERATIC LANGUAGE

The author, with his flute, testing the keynote of wing-strokes as insects are humming over flowers

number of vibrations on the basis of two hundred and fifty-six per second for the note C.[1] Tuning-forks are perhaps the most convenient instruments for such experiments, which may be made by any one who has an ordinarily good ear for musical sounds. The writer has used his flute with some measure of success. The house-fly has a wing-tone of F, or three hundred and fifty-two vibrations per second. The honey-bee strikes A, which means that it moves its wings at the rate of four hundred and forty times a second. When, burdened with its weight of pollen, the bee is on its homestretch, its wing-tone falls to E, indicating three hundred and thirty vibrations a second.

An interesting confirmation of these results has been made by fixing a fly within a carbonized cylinder revolved by clock-work. The tips of the fly's agitated wings left at every stroke a slight mark upon the smoked surface of the glass, which, being counted, gave substantially the same result as above—*viz.*, three hundred and thirty wing-strokes a second.

To be sure, such tones as these may be held to be a mere mechanical product or reflex; yet that they have the power to express certain ideas will be clear to one who will observe the effect produced upon a community of bees or hornets by the buzzing of one of their number when angry. The excitement runs rapidly from one to another, until many members are visibly affected. The original irate had certainly communicated her mood to her fellows.

Even insects of alien species seem to understand such wing-stroke language. Let an angry hornet or yellow-

[1] The most extensive studies in this interesting field are those of the veteran entomologist, Samuel C. Scudder.

jacket course the suburbs of a populous ant-hill, and the knowledge of her temper will be conveyed to the ants, who apparently understand that a highly keyed note is a threat which they must needs resent. It is a question how such information is conveyed; but perhaps, like a coursing motor-car, the intruder may give forth not only a hostile note but a pernicious smell!

Before entering further upon this theme, it behooves both writer and reader to remember not only the vast gulf which separates us from insects as well as the common bonds of nature that unite us to them. Entomologists have already disclosed much of the real life of the lowly creatures that share with us the earth; but we have as yet scarcely passed beyond the threshold of the temple of knowledge that Nature has reared around us. Many problems that have barely been stated remain unsolved or partly solved, though our scant knowledge might be far more complete "would men observingly distil it out." Innumerable other problems doubtless are beyond the screen, duly to rise as the horizon of discovery shall enlarge.

What know we, for example, beyond the narrowest bounds, of the senses of ants—of their number, their quality, their range? What know we of the endless degrees of sounds and shades of color that may form the world within which insects move, familiar to them, but a *terra incognita* to us? May there not be a Nature within our known Nature, worlds within our knowable world—like the successive enclosures within a Chinese "nest" of boxes—of which insects know, and wherein may be their largest moiety of life? To them a wild meadow, a flower-garden, a grove, or a brook-side may be a boundless scene of beauty and activity, friendly

and hostile, such as we might depict as a fairyland. Therein may be landscapes hidden from our eyes, with many grades of color, fair or grewsome, and octaves of sounds, pleasant or fearsome, that lie beyond human senses or even human fancy. Of this world, or these world-spheres, much must remain unknown to us—at least, in this cumbered state of existence. But to penetrate it further and further, to unlock its secret doors, to explore and disenchant its chambers of mysteries, and to interpret to mankind its inarticulate symbols—this is the highest function of the true natural history.

CHAPTER VII

HOW ANTS COMMUNICATE

WE are not yet done with our typical bee's capability to express her current feelings. She can resort to spiracular language. When deprived of the use of wings by the spider's entanglements, she still made her plaintive, or petulant, or wrathful protest through the spiracles. These are breathing organs arranged in pairs along the abdomen and thorax of insects. Behind each spiracle is a membrane, or chitinous projection, which is agitated during breathing, and may be set vibrating so rapidly as to produce a sound. This, for lack of a fitter word, has been called a "voice," and certainly suggests the product of the vocal chords in man. It comes as near to being a true voice as we are likely to find among insects, and perhaps the diminutive "voicelet" might be applied to it not inaptly.

One need not be a naturalist to satisfy himself of its presence. Let a house-fly be held by its two wings—our bee being hardly available for such an experiment for ordinary observers—and there will be heard a high-toned buzzing which manifestly is not made by the wings. It issues from the spiracles, and is the insect voicelet. The same note may be heard from the unhappy victims of fly-paper, who, though their wings are held in the grip of the sticky compound, continue to send out a pitiful cry from their spiracles. The same wail

or shriek may be heard from the unfortunate creatures whose wings have been burned off in a lamp or candle.

Another familiar member of the Diptera has the faculty of voicing—the mosquito, with "blood-extracting bill and filmy wing." The "honest" mosquito, that blows her shrill pipette to warn of her approach, produces her peculiar note by the use of her spiracles. It is doubtful if her chivalry in giving her chosen prey a chance for defence is appreciated. To many, the soundless sort that fall with the silence of death or "sable-vested night," and go straight to their phlebotomy and make no fuss thereabout, are the less pernicious of the two.

The bee's spiracular voicing is known among bee-keepers as "piping." The senior Huber [Hu. 1, p. 157] published the first intelligent account of it. When the old queen of a colony has left with a swarm, the new queen is sometimes seized with a fancy to sound her pipes, standing, while doing so, with her thorax against a honeycomb, and her wings crossed on her back—in motion, but without being unfolded. The sound has a remarkable effect upon the workers, who, with their faces toward the queen, lower their heads and remain motionless, as though smitten by some strange charm, and listen intently. The young queenlings, still within their cells, perceive the sound through the waxen walls that confine them, and respond thereto with what seem to be notes of defiance and challenge.

Even without such stimulus, the queenlings within the royal cells, while waiting to be freed by the workers, will play their pipes. The sound emitted Huber described as very distinct, a sort of clacking, consisting of several monotonous notes in rapid succession. He con-

jectures that the use of this piping, in the economy of Nature, is to give notice that the young queen is ready to be released—an office which the workers keep well in their own hands, in view of the instinctive tendency of all apian royalties to destroy one another, and enjoy through regicide, an undisputed reign. Whatever be the purpose of this ceremonial song, the fact is patent that piping is a mode of communicating certain emotions well understood by both queens and workers, and therefore serves the end of language. The worker-bees, upon the adoption of a stranger queen, will gather in a series of circles around the newly installed sovereign, and staidly vibrating their wings, sound a sort of coronation anthem, which, as it appears to issue from the spiracles as well as wings, may be classed with the piping of queens. [Hu. 1, p. 107.]

It is strange that an act which should have the benefit of the community in view should open a way to disaster. Yet so it appears. Huber was greatly disturbed by the ravages of an unknown enemy among his hive bees. At last the invader was found to be a large moth (*Sphinx atropos*), popularly known as the "death's-head moth" (Fig. 63), from certain body-markings that rudely resemble a skull and cross-bones. Experiments showed that the bees have ample power to defend themselves against this moth. In the case of the bumble-bee this power is used to sting it to death, those children of the wild being less open perhaps to the seductions of music enchantments than hive-bees with their more artificial habits. How could a moth, destitute of natural force and weapons fit to cope with throngs of insects which can repulse a man, manage to cow them or charm them and thus safely plunder their homes?

Huber's suggestion, which has been supported by other observers, was that Atropos has the gift of making a sound so like the "piping" of queen bees that the workers are deceived thereby, and stand inactive and

Fig. 63—DEATH'S-HEAD MOTH WHICH MIMICS THE PIPING OF A QUEEN BEE

seemingly fascinated, as is their wont under the real royal notes, while the moth works its will in their household. [Hu. 1, p. 312.] How strangely this bit of natural history suggests the stories of witch and enchantress that were wont to awe our credulous ancestors! Or, much to its advantage, did Atropos thus prove that "music hath charms to soothe the savage breast"? But the "music," like that which satisfies the average savage,

would hardly charm an Asaph, or a Haydn, or a Beethoven; for it is simply the grating sound produced by rubbing the palps against the base of the proboscis. But, then, the bees are not dainty in their musical taste, as witness our boyhood's recollection of a throng of excited villagers following a swarm of bees across the fields, with jangling of cow-bells and clanging of tin pans, moved by the traditional faith that bees would thus be charmed to "settle."

Thus we are brought to another form of insect language—stridulation. Our typical bee, unlike the Atropos moth, is not gifted in this wise. But the art is possessed by some spiders, and one species, akin to the tarantula, gets therefrom her specific name—*stridulans*. The insect music with which we are most familiar is thus caused. The organs which produce the various notes are built on the principle of the violin and mandolin. In other words, they are the result of regulated friction, though the degree of regulation is crude and limited.

Take, for example, the grasshopper, whose shrilling is one of our well-known autumn field-notes. On the inner side of the thigh is a series of fine cogs, or teeth, which one can see with the naked eye or with a hand-lens. These, rubbed rapidly against the wing-covers, as one might rub a file against a goose-quill, cause the grasshopper's rather cheerful chirrup (Fig. 64).

Brunelli, an observer of the eighteenth century, confined in a closet a bevy of male grasshoppers (*Gryllus viridissimus*), who proved quite philosophical prisoners; for instead of sulking, they kept up a merry fiddling all the day. A rap at the door at once stopped their note; but an imitation of their chirruping, which the naturalist managed to make fairly well, brought a low response from a few, which soon swelled into a chorus by the

whole group. One of the males was shut up in a cage in the garden, and a female captive was set at liberty near by. Soon the male put his mandolin into play, whereat Madame Gryllus flew to his side. "Barkis was woolin'"—and Peggotty, too! Certainly here was a case

Fig. 64—STRIDULATING ORGANS OF LOCUST AND CRICKET
RED-LEGGED LOCUST (MELANOPLUS FEMUR-RUBRUM)
Below it is shown a greatly enlarged section of the file on wing-cover of male cricket, against which the scraper on opposite wing-cover is rubbed to produce its call

of intelligent communication between two lovers, and that by means of sound, and not by scent alone. And it may be that for the most part this form of insect language is amative. So, doubtless, much of human speech was evolved around sexual and parental loves.

But Brunelli was preceded at least eight centuries in discovering that caged grasshoppers will utter their stridulant notes. According to the late Prof. Lafcadio Hearn,[1] the Japanese, as long ago as the tenth century, were addicted to their interesting habit of confining insects in cages for the sake of their music. To-day the sale of these insects and the dainty cages[2] in which they are kept is a large and lucrative business in Tokio and

[1] *Exotics and Retrospectives*, pp. 39–79.

[2] The writer is indebted for the two ingenious specimens here figured to Mr. Lucien Sharpe.

other Japanese towns (Fig. 65). To that remarkable people the shrilling of crickets and grasshoppers seems to be as sweet a sound as the song of canaries to us. One who deems this a barbarous fancy may be reminded that the men of classical Greece held the cicada to be sacred to the deity of music.

One finds such insect musicians as charm the Japanese everywhere around him in the fields during late summer and early autumn. Sitting here, writing, on the open porch of his country home, the author hears the notes of hosts of insects beating upon the hot noon air. Wild bees, yellow-jackets, brown wasps, and blue mud-daubers keep up a ceaseless hum as they hover over a flowering

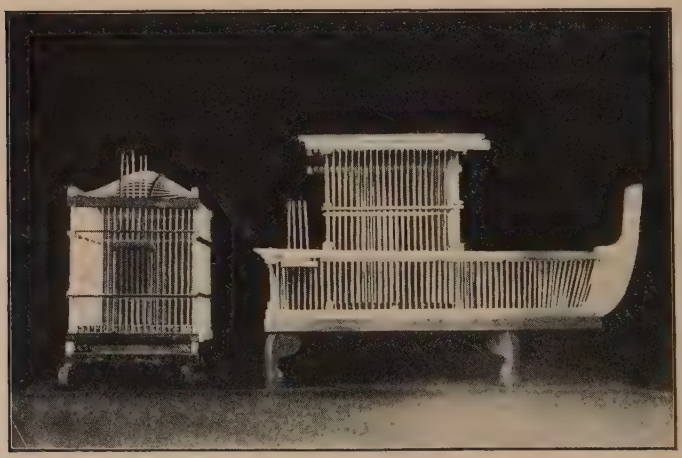


Fig. 65—JAPANESE CAGES FOR STRIDULATING INSECTS

vine that drapes and shades the railing. Just overhead hangs a fragrant clematis, among whose leaves a tree-cricket plays hide-and-seek with the writer, and interjects an occasional high-keyed *Kreak! kr-reak!* Out of

the grove issues the cicada's rolling call, swelling in volume and dying away, and not well ended till an answering or another trill is heard. And so, on and on—beech-tree responding to maple and chestnut to white oak, with hardly an interval of silence. When night falls "the katydid works her chromatic reed," not indeed "on the walnut-tree over the well," but on the beeches and oaks, beneath whose branches wind the wood-drive and the ramble. All these and others, with organs varying in structure, as is the wont of versatile nature, are the product of insect stridulation.[1] And could one tune his ear to the finer sounds with which the occult spheres of cosmos are full, he would hear many like sounds.

Ants, for instance, are supplied with stridulating organs, which, reasoning from analogy, they must use as means of expressing certain feelings. Yet one of the rarest events in insect ethology is the record of an emmet stridulation—unless, indeed, the rasping noise one hears issuing from the excited hordes of a disturbed ant-hill may be the aggregate of many stridulators instead (as conjectured) of the clatter of numerous mandibles and the grating of chitinous body shells as they rub against one another. The writer was long inclined to the latter view, although more than a quarter of a century ago, in his studies of the honey-ants of the Garden of the Gods, he showed that ants possess organs well fitted to produce stridulatory sounds, and cited at least one case that seemed to prove such use thereof. [McC. 4, p. 67.] But the evidence now in hand puts beyond doubt the existence of the habit.

[1] Rubbing the femora or the wing-covers together, and rubbing the bases of the two wing-covers (*tegmina*) together, are the chief modes of stridulating among locusts, grasshoppers, and crickets.

However, the ordinary listener should not be disappointed if he fail to hear these stridulatory notes, so delicate and faint are they. They belong to that occult realm of sights and sounds into which few of the more highly organized forms of life are privileged to enter, and not to the great company of insect musicians who fill our summer and early autumn fields and woods with their varied orchestration.

One who carefully observes the abdomen of a large ant, even with the naked eye, can see that it is made up of segmental plates, five above (dorsal) and five below (ventral). These plates are imbricated—that is, they overlap one another, like tiles on a house-roof. They are composed of epithelial scales, hexagonal in form, which present a beautiful appearance, as of delicate mosaics, when viewed through a microscope. When a profile view of one of these scales is exposed to the lens the serrate edge is clearly seen. Thus it is plain that a backward and forward motion of the plates upon one another might produce a faint rasping sound. All that is required for the complete conditions for stridulation is the muscular ability to perform this action rapidly (Fig. 66). Ants certainly possess this; and, in fact, they may be seen thus moving the abdominal plates in and out, back and forth, with a rapidity that seems to increase with their excitement. The many faint sounds thus made, inaudible in the individual, but audible in the aggregate, would account—in part, at least—for the peculiar hiss-z-z-z which arises from an excited column or colony of ants. It will also help to explain the popular belief that one sometimes picks up in rural parts, that "ants sing." Besides this grating of the abdominal plates over one another, there is a rotary movement of the base of

the abdomen upon the post-petiole which produces the same effect, probably even more generally than the above.

Professor Wheeler believes that stridulation is an important means of communication—at least among

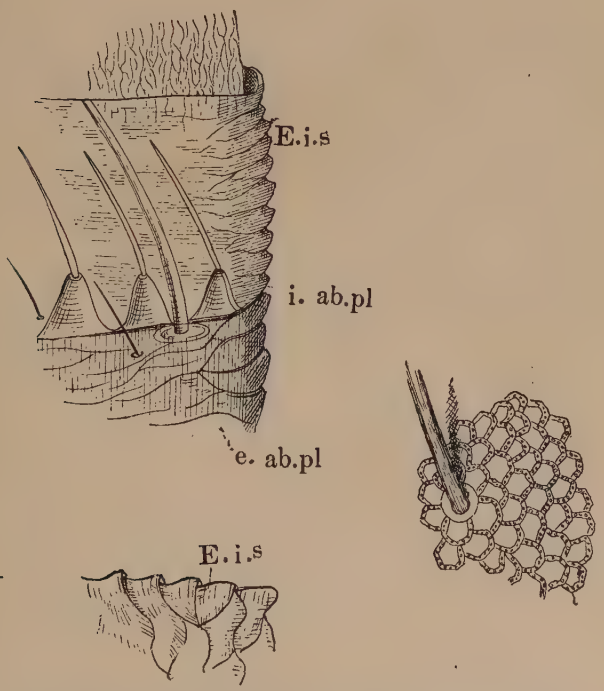


Fig. 66—PROBABLE STRIDULATING ORGANS ON ABDOMINAL PLATES OF ANTS. (MAGNIFIED SECTIONAL VIEWS)

E. i. s.—Epithelium; imbricated, serrate edge. *i. ab. pl.*—Interior of abdominal plate. *e. ab. pl.*—Exterior of abdominal plate

such ant families as the Mrymicinæ, Ponerinæ, and Dorylinæ. To this he attributes the rapid congregation of ants when particles of food are discovered by errant

members of their community. The pleased sensation of falling upon food is apt to start an ant a-stridulating, and thus other foragers abroad in the vicinage are attracted by the food-call. This also explains, in part, the rapid spread of the heroic rage to defend their home which runs through a populous ant city and calls out a legion of eager sentinels and workers.

Stridulation also accounts for the ease with which members of such species as the agricultural ant of Texas are trapped by sinking a glass jar or bottle on or near their formicary. One ant falls in, and begins to stridulate. The sound attracts passing comrades, who throw themselves over the rim to the rescue, and in turn, finding themselves imprisoned, begin to stridulate, until at last so many are sounding the alarm that the chorus is audible even to the human ear.

If, now, the jar be corked and shaken to further excite the inmates, and then held over another Pogonomyrmex commune, whose members are peacefully sauntering about, the wildest excitement suddenly seizes them, as though there had been a call to arms. The writer has collected these Texas ants by this method, but such a reasonable explanation for the clatter within the bottle did not occur to him until suggested by Professor Wheeler.

More decisive than the above, and it is conclusive, is the description of the remarkable stridulation practised by the leaf-cutting ants (*Atta fervens*) of Texas. Herein the different forms—from the huge females, through males, the large-headed soldiers, and the diminishing castes of workers, down to the tiny minims—present a sliding scale of audibility. The rasping stridulation of the queen can be heard when she is held a foot or more

from the ear. The male and soldier, to be heard, must be held somewhat closer, and the worker-majors still closer. The smaller workers and minims, though stridulating, as may be seen from the movements of the abdomen on the post-petiole, are quite inaudible to the human ear. We may safely join in the inference that "it is not at all improbable that all this differentiation in pitch, correlated as it is with a differentiation in the size and functions of the various members of the colony, is a very important factor in the co-operation of these insects, and of ants in general." [W. 4, p. 11.]

Such a condition, of course, implies that this stridulatory language is "heard"—that is, produces an effect analogous to that of hearing. No auditory organs have yet been discovered in ants with such positiveness as to establish their existence beyond question, although minute bodies within the tip of the antennæ are believed by some observers to serve as such in part. But that their behavior under certain conditions is quite constantly precisely what one would expect were ants known to have ears, or their equivalent, is easily seen. Whether they hear or not, they respond to sounds in a way corresponding to the acts of creatures that have ears, and do undoubtedly hear. It is manifest that this must have a vital effect upon the government of ant communes to which, as in all other governments, some means of intercommunication are essential.

Last of all, and perhaps most important of all, as a means of intercommunication, is antennal language. Ants, in common with most insects, are provided with a pair of peculiar organs known as antennæ, located upon the face, above the mouth and midway between the eyes. Externally these are thread-like rods of greater or less

length and thickness, jointed, and articulated upon the face to increase their flexibility. In ants they consist of two parts: the scape, a single piece that unites them to the head, and the flagellum, composed of a number of segments ending ordinarily in a bulbous tip.

The olfactory sense has its seat in the antennæ, usually in the flagellum or the pore-plates and olfactory rods thereof. While ants are sleeping, as observed in my artificial formicaries, the antennæ have a gentle, quivering, apparently involuntary movement almost like the regularity of breathing. [McC. 3, p. 134.] It seems as if these sentinel organs keep on duty even during sleep, guarding the approaches to their unconscious possessor (Fig. 67).

Livingstone [Li. 1, p. 576] gives a good example of the dependence of ants upon the sense of smell as lodged in

Fig. 67—THE FACE OF AN ANT, SHOWING THE FLEXIBLE ANTENNÆ

the antennæ. He states that certain African species, which he designates as "soldier ants," when on their pillaging excursions, if their trail be covered with soap and water or with fresh earth, will halt in apparent confusion, and the succeeding ranks will mass in great numbers at the point of stoppage. Meanwhile their

"leaders," who seem to act as scouts in scenting the trail, will diverge from the column, flank the obstruction, and recover the trail. Whereupon the main body move around the tainted section and proceed upon their way.

In the antennæ of ants are concentrated a great degree of diverse sensibilities. The sense of hearing (probably in whole); a large measure of the function of sight as it exists in other insects and higher animals; the faculty of communication (language)—all seem to be located in the antennæ. They probably surpass in sensibility anything at the command of higher animals, or even of man. [C. 1, p. 210.] They are not only the prominent guiding organs, as in insects generally, but are rendered peculiarly sensitive by the addition of delicate hairs, some of them highly specialized, spread over their surface. Besides, they are articulated to a degree which gives great flexibility and permits a variety of movements in their use.

The removal of the antennæ produces an extraordinary disturbance in an ant's intelligence. It can no longer find its way or recognize companions. It ceases from its usual tasks, from seeking food, and from caring for the larvæ. Its condition recalls descriptions of the consequences of removing the frontal lobes from the brain of higher animals. The analogy is so close as to suggest that the antennæ of ants, with a brain adequate for their functional requirements, are equivalent to the most important parts of the brain of higher animals working with inferior sensory organs. Such organs of sensibility as those possessed by ants are a specialty in sensory organism—a conspicuous illustration of sensory power concentrated in an external organ. "Their loss

is equivalent to the destruction of the mental faculties." [Ro. 1, p. 142.]

Darwin's remark, that "the brain of the ant is one of the most marvellous atoms in the world, perhaps more so than the brain of a man," must be taken with a measure of qualification; at least, the word "brain," as used by him, must be understood in connection with the antennæ, the special organs of the sensori-motor system of which the brain is only the governing centre.

We may remark in passing that, in considering the intelligence of ants, the sensory organs afford the key to the situation. They are the real test of intelligence or power of discrimination. They are a specialty in animal life, and, as remarked by Professor Calderwood "the ant's intelligence is in keeping with the recognized functions of the organs of discrimination at its command." [C. 1, p. 216.]

The popular name of antennæ is "feelers," and it is a quite fitting one; for when ants are awake and in action these organs are kept continually revolving in front of them and on either side of their path, touching the various objects met, and sweeping the foreground as though to feel the way. That, in fact, is their chief use; they are feelers. With ants they are, perhaps, even more important than the eyes for personal locomotion and service and communal action. They determine the forms of objects; they locate the individual trail and the path of its fellows; they distinguish foes from friends; they test the quality of food and of all other bodies, both by their odor and by their tactual reflex; they give definite perceptions of space relations, and thus enable insects, while moving over the ground sur-

face and through the ground closure, to orient themselves, and make sense record for subsequent use as a rudimentary sort of memory.

It is this remarkable structure that so highly qualifies the antennæ for the function as the chief organ of com-

Fig. 68—THE CHALLENGE WITH CROSSED ANTENNÆ

munication between ants. One cannot observe a colony or a moving column of ants for any length of time without seeing how constantly the crossed antennæ are used, obviously for communication. On the great dome of the Alleghany mound-makers, and on their tree-paths and the trails leading thereto, sentinels reach out their antennæ in challenge, and receive in the same way a response. Two errant foragers meeting on the hunting-field invariably cross antennæ (Fig. 68). Going or coming, leaving home or returning, on the city premises or field, it is always the same. One reads at once from the manner the mutual "All right!" which passes. Whether conveyed by odor or by contact or by both,

one may not affirm. But that it is conveyed, he readily sees.

Two battling armies of the pavement ant (*Tetramorium cæspitum*) are massed on the edge of a flagstone walk. A column of highly excited warriors is streaming from the scene of action to the home nest of one of the combatants, from which issues a group of peaceful citizens. The two lines meet. Antennæ are crossed, a quick, sharp action, and the messengers—for such they are—hasten on homeward. Note the result. Some mysterious influence has passed from one to another. The peaceful citizens are transformed into combatants raging with the lust of war, and with every bodily member a-quiver, rush into the thick of the battle hurly-burly to reinforce their comrades. Was there not antennal communication between couriers and recruits?

Here is a case recorded by Lord Avebury [Av. 1, p. 75], which strikingly illustrates this function of antennæ. A worker of the dark Lasius (*Lasius niger*) was occupied in carrying off larvæ to her nest. At night she was imprisoned, and, being released at 6.15 A.M., immediately resumed her occupation. At 9 A.M. she was again imprisoned until 4.40 P.M., when she was put once more to the larvæ. She examined them carefully, but went home empty handed. At this time no other ants were outside the nests. In less than a minute the original worker, which had been marked with a dot of paint, came out with eight friends, and all trooped off toward the heap of larvæ.

When they had gone two-thirds of the way the marked Lasius was imprisoned, whereupon the others hesitated for a few minutes and then returned home. They evidently missed their leader's guidance. At

5.15 P.M. the marked ant was again put to the larvæ. Once more she went home empty handed, and, after only a few seconds' stay, came out of the nest with thirteen friends, and all went toward the larvæ.

In this case the twenty-one ants must have been brought out by the marked one, for they came exactly with her, and no others were out. Moreover, they must have been told, since in neither trip did she bring a larva with her, and the sight thereof could not have led to her being trailed, though of course it is just possible that a faint odor clinging to her from contact with the larvæ may have given a signal that caused her to be followed.

Good examples of antennal parley occur in the predatory expeditions of slave-making ants. From the nests of the sanguine slave-maker (*Formica sanguinea-rubicunda*), studied in New Jersey, scouts were seen to be sent out to discover and locate the nests of the Schauffuss and Fuscous ants (*Formica Schauffusi* and *Formica subsericea*). When these were successful, they hastened home with their antennal message, and soon the plundering raid was in full heat. Forel describes the same conduct as habitual with the amazon ants (*Polyergus rufescens*) of Switzerland. Moreover, he relates that in case of uncertainty as to the right route, the column will halt, and wait while the scouts go forward and locate the nest of the predestined victims. Returning, the antennæ play vigorously between couriers and column, and the piratical excursion advances.

One example more. At Faisons, North Carolina, Doctor Forel, during his visit to the United States, found in a rotten log a nest of the totally blind little *Eciton Carolinense*. He captured the colony, and put it under observation. The ability of these ants to find their way about

rapidly and unanimously in new territory without one estray seemed almost incredible. They were transported to Washington, where a handful of them, with their young, was thrown into an open garden. Without losing a moment's time the wee blind creatures began to form in files, which were fully organized in five minutes. Tapping the ground continually with their antennæ, they took up their larvæ and moved away in good order, like well-drilled soldiers, reconnoitring the strange region into which they had been cast. Every pebble, plant, crevice was tested with the antennæ, and the place best suited for concealing their young was soon found. Most other ants would probably have been an hour in accomplishing this. The experiment was repeated twice with the same results.

The marvellous fact in this action is the certainty and quickness with which the "topochemical trail"—to use Forel's phrase—and the company relationships were recognized. The groping about, and wandering to and fro, and hesitant mien, common to ants when first placed in strange sites, were wanting. We are prepared, therefore, to learn that the antennæ of these Ecitons are highly developed. And we share the interest of the learned observer who watched the *perpetuum mobile* of those organs, as in the most lively manner they kept titillating the ground, their companions, and all surrounding objects.

CHAPTER VIII

FEMALE GOVERNMENT IN ANT COMMUNITIES

THUS far our studies have been chiefly of the exterior of the ant commune. We are now to take a view of its internal economy. The reader may have noticed that the author, in referring to the insects under observation, gradually passed from pronouns of the neuter to those of the feminine gender—or, rather, has used the two interchangeably. This accords with facts. The worker ant, although in common parlance a "neuter," is structurally a female. In her the special function of the female, to produce the eggs from which the young are reared, has been subordinated, though not wholly atrophied; for workers occasionally drop eggs, which are cared for, and which yield males.

Other faculties have been developed or have appeared needful for communal safety and prosperity, and thus it has come about that the government of these emmet societies, as with bees, hornets, and wasps, is really a gynarchy, or government by females. Our worker ants are veritable Amazons. Not only does the entire domestic control and service of community fall to them, but also those more virile acts (according to human standards) of war and public discipline and defence. To the fact that the female temperament dominates affairs we may perhaps attribute many of the characteristics of public administration among social insects.

That there is a "female temperament," sharply distinguished from that of the male, is obvious enough to the student of emmet habits. That its dominance is advantageous to these organizations the natural history of the Hymenoptera attests.

What would be the effect upon human societies should similar conditions prevail among them? As a speculative theory it is worth discussing, and one would hardly err in thinking that our public and official affairs would be greatly bettered could woman's temperamental view of things have wider influence therein, especially in their relations to the young. Our civil governments and their administration, from the township to the national capital, are almost wholly products of the male element of the race. The predominance of the female element, which one sees in ant communes, might not be desirable in our present stage of civilization, although it would be an interesting experiment in a county or even in a State. Such illustrations as the United States presents throw little light upon the problem, for the general conditions of society in the States that give woman the suffrage really differ little from those prevailing elsewhere. They certainly fall far short of the female status in an ant commune. One may safely think that a great deal more of it would be to our advantage. The fact to be especially noted is that among ants, as also among other insects, nature has built up upon the female organization, and not upon the male, the most remarkable and successful examples of social life and government known to natural science — the ant commune, the beehive, and the hornet's nest.

In the internal view of an ant commune's affairs the most striking facts are the relations of the queen mother.

Her queenhood is wholly fanciful, except in the first stages of her independent career. Her motherhood is the great fact of life to her and her fellows. It is as a mother that she is the destined foundress of a new community. After her isolation or adoption into an established commune, which follows the marriage swarm, she begins to lay eggs which are developed into workers in due time.

If she goes solitary, her larger size and generous nurture have accumulated enough substance to supply

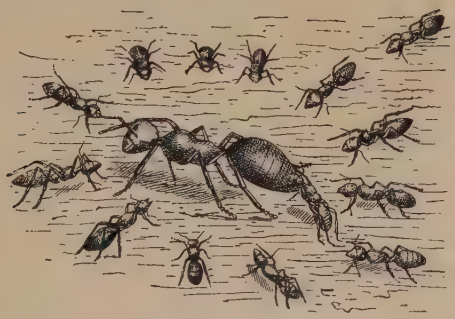


Fig. 69—(A) QUEEN ANT SURROUNDED BY HER COURTIER GUARD,

food to the initial colony with little or no outside foraging, and this is imparted, after the manner of her kind, by regurgitation. All the duties of nurture, nursing, washing, keeping up and keeping clean the premises, are wrought by her within her secluded and protected quarters until a little band of helpers has been reared around her. These at once begin to share labors with the queen mother (Fig. 69).

When they have passed their callow period, they break the original bounds and venture forth in search of food. Day by day the number of inhabitants increases; the

formicary is enlarged by cutting out and building up new rooms and galleries; perhaps a new site may be chosen. A wider range of foraging is compelled by the needs of the growing community. The various labors, carried on at first by the queen, and afterward by the few pioneers, become more and more specialized, until at last are developed the vast and divided industries of a large and fully organized ant commune.

Meanwhile a remarkable change has befallen the queen mother. The workers, as their number grows, have taken on more and more the responsibility of labor and administration, until at last the whole burden thereof is lifted from the queen, and she is limited to the function of motherhood (Fig. 70). She lays the eggs from which new citizens must be recruited, a service which increases in importance with the expansion of the community. Not only have the labors enlarged, but the wastage of life has greatly increased through accidents by flood and field, and perils of farther adventure into a world full of strange creatures who prey upon them, as do birds and divers beasts; and who war on them, as do sundry insects and ants of alien tribes. Across their trails come cattle and men, whose ponderous feet crush them unwittingly or carelessly.

Every day has its list of casualties, very large at times. Every morning sees many who venture forth in quest of food supplies for dependents and home-workers, bounding with vigorous life and highly intent upon useful service, who never come back. When evening comes, at the gates of their loved city no watchful sentinels greet them. No eager nurses, or hungry antlings, or comrades weary with toiling on the works, shall lift up lips for sweet refection, the garnering of the day's ad-

venture. Somewhere outside the city bounds, it may be near by, it may be afar, there has been a tragedy that no annals shall record and no ballad sing, but which

Fig. 70.—A PEEP INTO AN ANT COMMUNE Showing the queen of *Lasius Niger* in the midst of the workers. (After Lord Avebury.)

robs community of a useful life, and cuts down a happy worker in the midst of a wholesome career. "Only one ant!" Yes, it is not much in the vast fecundity of nature, and is easily replaced. But it is an atom in the world's order that no human power can restore.

So, in the larger field of industry and research, our race has its daily tragedies, not wholly unlike these which befall the citizens of an ant-hill. The martyrs of industry, heroes, and heroines; the fallen soldiers of the great army of labor, are thus going forth daily to perish in the path of duty. It is said that one out of every eight adult persons dying yearly in Pennsylvania dies a violent death. Not wholly, but too much, far too much, like the indifference of ant communities is the indifference of human society to these industrial tragedies. And the rational excuse of the ant is not for us, for nature has not made us that way. With us it is mainly wicked hardening of heart. How shall we cut down, if we may not wholly cut out, the long list of such wasted lives? Meanwhile, how shall we provide for the maimed, and for the dependents of the slain? Are not these soldiers of industry also worthy of communal care?

"Breed more workers!" is the answer of the ants. The circle of their instinct has no wider swing. But at least they will make sure that the supply is sufficient, and the standard of wholesomeness and efficiency is kept up. And so the queen mother must be encouraged to her utmost productivity, and every egg dropped must be preserved and reared with utmost care.[1] A peep within the city walls will show a rare condition. The whilom sole potentate who, first in solitary power, and then in maternal sovereignty, and next in undisputed matriarchate, held unchallenged authority and the exclusive right to labor, is seen in a large vaulted chamber in the heart of the galleried cone. She is not alone, but is surrounded by a circle of workers. Is she a prisoner?

[1] In my work, *Nature's Craftsmen*, chaps. i and ii, readers will find a rather full and connected account of a queen ant's life.

—a sovereign deprived of queenhood, and in the hands of regicides? Not so bad as that! The offices of the guardians are at least friendly. They are a body-guard; in fact, the so-called "courtiers" of the ant queen—a phrase of courtesy, as is the word "queen," for the days of sovereignty are over, and these keepers of the sacred person are saying to her, in this decided way:

"God did anoint you with His odorous oil
To wrestle, not to reign!"

Fig. 71—WORKERS TAKING EGGS FROM THE QUEEN MOTHER

And here you may see a fair example of the sort of "wrestling" expected of her. She has paused in her march around the room. She raises her body well upon the hind pair of legs. See! From the oviduct beneath her abdomen she forces a minute, white, ovoid object which has no sooner dropped than one of the body-guard rushes from the inner circle, seizes it in her jaws, and hurries therewith from the chamber (Fig. 71). It is an egg—the norm of a future citizen! The process described will be repeated over and over again, many thousand times, until the ovaries are exhausted or death shall intervene.

It is to save these precious particles of living matter

for the community that this circle of watchers continually surrounds the queen mother's person. Theirs is a tribute to motherhood, not to queenhood. Certainly they have not reasoned it out, but instinctively they know that the prosperity, the very life, of the commonwealth depends upon the maintenance of that fecundity whose cessation would be "race suicide." Popular fancy has brought to the explanation of this "royal body-guard" the familiar lines:

> "There's such divinity doth hedge a king
> That treason can but peep to what it would."

It will be seen, however, that this "hedge" about our ant queen amounts simply to a case of communal vigilance, represented by watchers set by the self-governing majesty of the commune to save all the ant eggs possible. Doubtless there is "divinity" in it, as there is in all honest discharge of duty and outworking of nature's laws. But anything like regard to sovereign state, or purpose to give or maintain royal honors, is wholly foreign from the situation. Reverence for motherhood is there, however—wholesome and protected motherhood, the essential fountain of communal virtue, vigor, and perpetuity. Are we losing from our own race the due reverence of that "divinity doth hedge about" maternity? Woe to the nations or peoples, be they ants or men, in such estate!

The body-guard of an ant queen is an elastic ring that expands and contracts with her movements. If she move around the room they move with her. If she seek an adjoining apartment, the ring precedes, accompanies, pursues, but never breaks up. Sometimes the guard conceives that her maternal majesty needs special guid-

ance, a very courtier-like and cabinet-like conception. Then one will see her bulky body gently solicited by a pull upon her sensitive antennæ made by a worker-minim, or a tug at a leg by a worker-minor, or a push or pinch upon the abdomen by a worker-major (Fig. 72). A sort of volunteer steering committee are these; func-

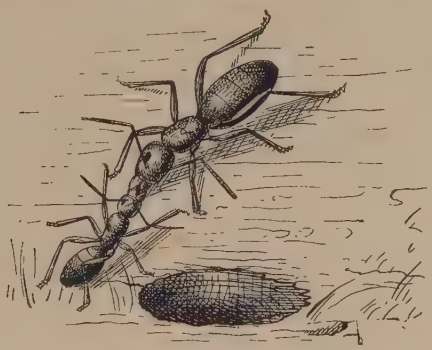


Fig. 72—A TRUANT QUEEN BROUGHT HOME

tionaries apparently needed, or at least present, in all organized governments, but coming as near to the vanishing point in ant cities as is conceivable.

Leaving the queen and her body-guard, let us follow the fortune of the egg. From the queen mother it is carried into a separate room, presided over by attendants who have received the not inapt name of "nurses." There is nothing to distinguish them as a separate class. They are on duty at that point for reasons satisfactory to themselves and to the secret but all-sovereign Spirit of the Commune, whose mysterious sway all freely obey. It does not appear that there has developed a special class of workers with the charge of the communal young as their chief function. Nor are such duties assigned to the maimed, or to the toothless members, whose jaws

have been worn down by age and by the gritty and stubborn material upon which they must labor. The nurses seem to be in the prime of anthood, vigorous and efficient.

It does appear, however, that the callow antlings, just out of their cocoon cases, are found among the nursing squads. They lose no time in taking up their life's work as helpful citizens—for which they enter imagohood full panoplied—but fall-to where opportunity first serves, and take care of their larval fellows. Until their shelly bodies become well indurated, they do not usually venture out-of-doors, but engage in tasks to which they are physically better adapted. This is a part of such education as they are to receive; for ants, like children, profit more by examples than by precept and criticism. The models of active public servitors are before them, and they simply do what all around them are doing. But the whole field of labor lies open to these prentices of the State, with no restrictions thereon.

The eggs soon develop into minute larvæ, fragile and helpless things that need close and constant care to preserve them in life. Owing to the social conditions of their being, they do not have that sturdy hold on existence, and power to care for themselves that mark solitary larvæ, or such as those of moths, that are gregarious in their larval or caterpillar stage. Thus from the beginning and throughout their growth—and they grow rapidly—they must be fed and cared for. Their care is always a first consideration. In the wreck of an ant city the workers may be seen to grasp the eggs and the young, and, careless of themselves, run to and fro, seeking places of refuge for their helpless charges.

One will see them in little heaps, often graded accord-

ing to size, scattered throughout the nurseries. No observer has yet conclusively noted such treatment as prevails in beehives, where male and female eggs are separated from ordinary workers, and a queen can be developed from a worker larva by enlarged quarters and specially enriched food. The larvæ of all ant castes and sexes seem to be kept in common and to receive like attention. The nurses continually hover over them. They lick them as a cat does her kittens. The larvæ learn to perk up their wee black heads and open their mouths, into which the nurses place food and drink. They shift their positions from side to side, sometimes from room to room, sometimes with apparent good reason—often, one fancies, simply from the overflow and outgo of such maternal sentiment as leads a young mother to dandle and fondle her infant offspring, cooing the while her love-phrases or love-songs; a spectacle truly pleasing—to the observer at least, and doubtless often to the infant. Certainly herein the female temperament shows its supremacy (Fig. 73).

Some readers who, like the author, have seen service in active military campaigns, know that male soldiers can be organized into a hospital corps for effective nursing of sick and wounded comrades. Many of us carry remembrances of how bravely and well, with what devotion and fidelity, this duty has often been done. Here and there, too, men have developed special qualities that have made them pre-eminent in the delicate and difficult service.

But what veteran, who has had the opportunity to observe, has not noticed the vast change that the entrance of trained female nurses has brought into the field? There are deftness and sympathy and tender-

ness—a something indescribable, but most potent, which women bring with them and which men have not—that work a transformation in scenes where human dependents are to be ministered to. These qualities are the fruitage of the female temperament. They spring out of physical organism, which so largely influences habits.

So, too, we all have known men whose love of children

Fig. 73—AN EMMET NURSERY FOR THE YOUNG

has been strong as death, and has made them good and careful nurses in an emergency, and for a limited period. But that man is indeed a rarity who is a proficient in the care of immature infants. Men may dandle young babes with delight and even success for a while. But the tact, patience, enduring fondness, and instinctive knowledge of the real natural nurse of infants are endowments of the female temperament alone.

It is certainly so among ants. The males are simply nonentities in the care of the commune's dependents. They are themselves dependents of the most absolute sort. Nature has denied them the gifts requisite for effective service. To one who knows them well, and their temperament and ways, it would never occur to think of them as caretakers for the nurslings of the commune. And this judgment is not affected by the occasional and very rare instances in which male ants have been seen to make some slight and awkward approaches toward a seeming part in the ordinary worker's duty.

For the most part, nurse ants take up and go through their duties in a business-like spirit and way. It is done thoroughly, and does not cease until the larvæ have spun up around them their silken pupa-cases. Nor then; for these cocoons are constantly watched, cleansed and cared for, and when the time comes for the young imago to escape, it is aided by the scissors-like jaws of the nurses, whose obstetrical services are aided by the efforts of the outcoming nymph.

Did Lycurgus get from the ants among his Spartan hills a first suggestion of his theory that children are a communal possession, to be reared at the charge and with the oversight of the State from the earliest age

practicable? Certainly, our American Republic is well impregnated with the germ of that theory. Its essential spirit largely controls the subject of education. True, we have not yet reached the high stage of ant government, in which the whole aim and activities of the commonwealth pivot upon and move around the rearing and care of the young. But, at least, it is a ruling theory of our people that organized society owes every child a common-school education. At a tender age our children are separated from their homes for a part of the day, and placed by the State—by legal compulsion, if need be—where they get training and instruction without regard of social distinctions.

Herein is the common meeting-ground of all classes at the most impressionable period of life, and the maintenance of the true democracy of our republic depends largely upon that fact. We carry the principle so far that we not only provide school-houses, teachers, school apparatus, fuel, light, and janitor service, but we supply text-books for the scholars. In many sections their car-fare to and from school is paid; or, as in a district school hard by the writer's country home, a big omnibus goes the rounds o' mornings and gathers up the pupils, and again at evening calls for and distributes them to their homes.

We dare not have it otherwise. Government must continue to be responsible for the education of its young citizens. For, however willing, individual families are not able to do this unaided by the State. Even the wealthy must submit to something like the same law. Said a multi-millionaire to the writer: "We shall go to Southern Italy to spend the winter. We might as well close our house. To-morrow our son goes to (naming a

college for men), and our daughter returns from Europe to go to (naming a college for women). Our only other child is married. Our home will be empty. We will go abroad." Thus the wealthy parent is not exempt from the necessity of committing his children to society to educate and train for future citizenship.

So it is in all higher education—classical, scientific, mechanical, professional, military, and naval. Organized society becomes, and must become, a nursing mother to the youth from whom, for the most part, her future rulers and most useful servants must come. As for the young waifs of society—the flotsam and jetsam of child-life, continually tossed amid the wreckage of the world's great social sea—long since government has seen, and sees it more and more, that they are in an especial sense the children of the State, and must be adopted and trained into citizenship by the State. Thus far, at least, our commonwealths are swayed by theories and have taken up practices long ago prevalent in ant communes.

Unhappily, our system breaks down where that of the ants proves splendidly effective: by our absence of system in providing work for young citizens as soon as their working powers are mature. In the ant commune every individual passes at once from pupahood to the status of a laborer. In a human community the citizen's work, in both fact and form, is left chiefly at haphazard. It must, indeed, be that with us, as with hymenopters, the Spirit of the Commune has some subtle potency in directing unconscious youth to the choice of occupations and keeping the working mass in activity. But the State as a State eschews the matter, and there is no sense of communal responsibility that every citizen

throughout life should be employed steadily and usefully. Might it not be that if there were more of the female element in the governing of our communes, there would be far less of that waste of steadfast and regulated industry, through lack of early discipline of citizens, which is such a fertile source of loss of character and profitable activity?

CHAPTER IX

THE PROBLEM OF COMMUNAL DEPENDENTS

WHEN one considers the incalculable hosts of ants that inhabit all parts of the earth, and that every individual thereof has been reared, from egg to imago, by the direct personal care and toil of adult members of ant communes, he may have some conception of the immensity of the labors involved therein.

It would, perhaps, be pushing metaphors to an unwarranted extreme to speak of "dignity of labor" in connection with the occupations of ants. But if by the phrase we mean that labor is the honorable lot of all citizens, and that all labors of whatever sort are upon the same level of respectability, then we might venture to apply the saying even to the labors of an ant-hill. For therein all are workers—from the newly fledged callow to the veteran of a second summer.

Therein is no taboo upon "hand toil." All forms thereof are equally creditable. We are reminded of the simpler state of society in the pioneer days of the United States and Canada and the British colonies. Indeed, it is the natural social order of human communities, until great possessions, earned and inherited, or usurped, or fortuitously acquired through communal increment, create a favored class. Surely this is an ideal republic—no idlers, no tramps, no citizen-parasites, no misers, no spendthrifts, no paupers!

This inviolable law of the emmet republic needs to be restated when we come now to consider what seems to be an exception thereto. We have seen that the population of ant communities is largely composed of the larvæ and pupæ, the helpless younglings from whom the future citizens must come, and whose nurture is the chief aim of the active commonwealth.

These immature dependents are so numerous that one would think that they alone might tax the resources of any society. Nor is it simply a problem of crude labor, quantitative energies, herein involved. As an outside intelligence views the situation, there is a large field for the exercise of qualitative energies, also, in the rearing of these youngling ants.

We have already seen how the squad of so-called "courtiers," in a circle of ceaseless vigilance around the fecund queen, manages to secure the eggs and transfer them to the charge of the nursing detail. It is manifest that the process by which these minute specks of vitality, that carry within them the future of the commune, are tended—cleaned, fed, shielded from changes of weather and all hostile influences—must involve a good deal of delicate and discriminating care.

The eggs soon become larvæ, small, soft, and extremely fragile objects, which need dainty handling to nurse into vigorous life. They grow rapidly, and one must suppose that the portioning of food to the changing grades of age and strength requires such qualities as we are wont to ascribe to a considerate mind. Again, as the larvæ pass into the pupa stage they demand a different character of treatment, which must call into play faculties, or at least activities, that with men would imply reflection and wise selection and decision.

Besides the fertile queen, or queens, and the host of brooding larvæ, our ant community is taxed with the support of the winged virgin queens and males (Fig. 74). For ants are not apterous insects, unless we take the worker as the original type of the order. The parents of

Fig. 74—YOUNG WINGED QUEEN OF HONEY-ANT (SIDE VIEW)

nearly all known species have, and from a remote period have had, wings. These have been lost to the maternal stocks through the exigencies of an underground or interarboreal habitat; and the winged forms have been preserved in females and males to favor that flight and commerce in the air by which species have been preserved and distributed. The swarming of winged ants on a soft September day is a sight not easily forgotten by a new observer, and which is not apt to lose its interest to the adept. As often as the writer has seen it, he still feels the thrill of excitement that pervades the commune, as he sees the hosts of winged creatures pour out of the formicary gates.

Here, beneath a young apple-tree, is a nest of *Lasius flavus*, whose existence had not been suspected until, in passing it, the free soil around the trunk was seen to be alive with a seething mass of yellow ants—males, females, and workers intermingled. They ascend the tree, whose surface is fairly covered with them. The gauzy wings of the sexed forms glisten in the sunlight as they march along. The workers hurry back and forth among the hordes upon the ground. Some join the column upon the tree trunk. They seem to encourage their winged protégés to take flight, even nipping them at times with their jaws to hasten departure. They are in a fever of excitement.

And well they may be; for this is the grand event to which a good half of the summer's work has steadily led. Thenceforth the commune shall be free from the immense burden of supporting this army of non-workers. How many of them there are! Numbers are continually taking flight. Away into the brilliant sunshine they soar, until they are lost to sight, the females alone and not accompanied by mates, as I have observed in other cases. Their fecundation had been accomplished within the nest. Others still are streaming out of the city gates to join their winged comrades on the tree.

Like scenes are enacted at two other points—the farthest twelve feet distant, under a young pear-tree; the nearer in a shaven orchard sod, midway between the two. These three centres of agitation seem to be parts of a common movement of one great community, whose subterranean quarters intercommunicate across the intervening space. Ere nightfall the crowds of winged forms have disappeared and the city gates are solitary. And this throng of creatures, many hundreds of them,

had been wholly dependent for food and care upon the workers of the colony during the entire summer.

Again, on a warm day late in June or early in July, one may see the air, at a short distance above the ground and for many square yards around, filled so thickly with flying insects that they seem like a thin cloud of quivering mist. They are the sexed forms of a small species of Lasius, whose inconspicuous nests are spread numerously over the lawn and field.

Many of these make their exit and marriage-flight at the same time (Fig. 75). They rise and fall, and weave in and out through the quivering air in their mating evolutions, sporting in the sunlight. They fill one with wonder that such a feeble folk as rule the weak communities whence they issue could bear the burden of nurturing into maturity such swarms of dependents.

But considerable as are these outputs of non-workers, they do not strike the imagination so forcibly as some of the well-authenticated accounts of immense marriage-flights of ants that have been published.[1] It seems incredible that the whole surface of a lake—of two lakes, in fact—should be covered so thickly with these winged creatures that they could be pushed up by passing boats into windrows several inches high and extending from shore to shore on all sides, as in the observations of Mr. W. C. Prime on Lake Lonesome.

It is interesting to note that this is not a novel occurrence. Such disasters have marked the history of flying ants from the earliest ages. Professor Wheeler spent the summer of 1906 collecting in the Florissant fields of Colorado, noted for their rich yields of fossil

[1] For details, see author's *Nature's Craftsmen*, chap. ii, Harper & Brothers, New York.

insects and spiders. This ancient Florissant lake-basin lies among a series of low-wooded hills and ravines. At the period of the Oligocene division of the Tertiary geological era this elevated lake must have been a beautiful sheet of fresh water. It was hemmed in on all sides by granitic hills, whose wooded slopes came to the water's edge—in this phase not unlike Lake Lonesome, among the White Mountains. Professor Wheeler's collections, which I have been permitted to examine, show the fossil ants to be more abundant than any other insects. But only males and females

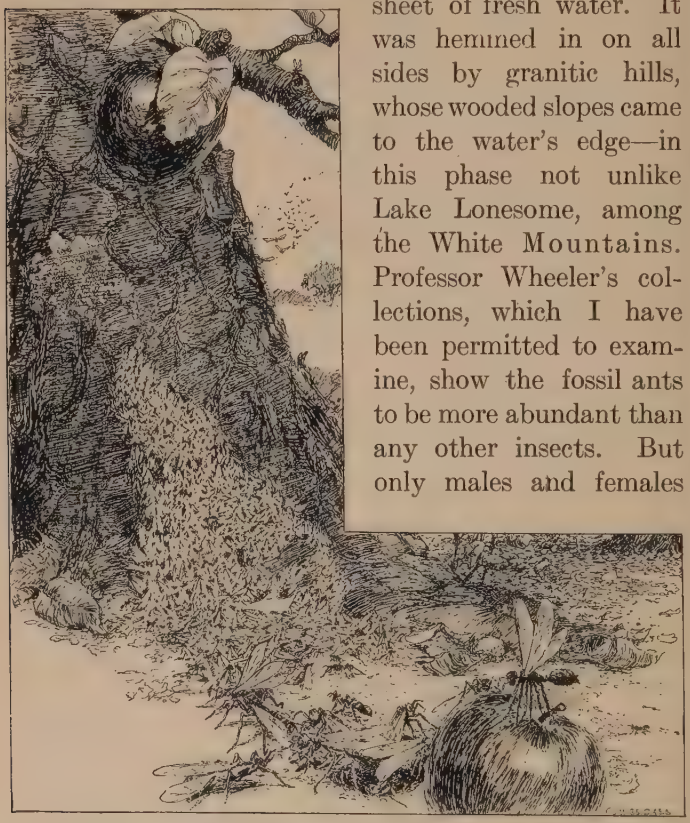


Fig. 75—A MARRIAGE-FLIGHT, OR "SWARM," OF WINGED MALE AND FEMALE ANTS

are represented, indicating that these had been submerged in the lake during marriage-flight, precisely like those reported by Mr. Prime.

Thus the vast interval between the present and the Tertiary eras is bridged by a continuity of habit which joins in substantial unity of social behavior the ants of to-day with those of far geological antiquity. In harmony with this is the statement that all of the eight hundred specimens secured belong to extinct and undescribed species, and are wonderfully like existing forms. It is substantially the same story that one reads in the even better preserved ant forms of the fossil amber of Europe. The *Formica fusca* of the Baltic amber, for example, appears to be entirely identical with that of the present. Much the same general conclusion arises from a study of the fossil spiders.[1]

In every such case as the fossilizing of the Florissant ants and the swarms of Lonesome Lake, the innumerable hosts of insects massed within a comparatively limited field must have come from a great number of nests dispersed throughout the general locality. We may conclude that the cycle of maturity was completed simultaneously in all these communities, and that similar favorable conditions united to induce contemporaneous flight. The intermingling of the various individual swarms, as they were borne along by the wind, sufficiently accounts for the extraordinary massing of winged creatures which were swept over and into the White Mountain lakes. This will not wholly explain the phenomena; for the virgin queens and their male partners, in full maturity, have often been seen to be inhabitants of the commune for a considerable period before marriage-flight. Evidently they are prepared for the exit long before it comes, and await therefor

[1] See author's *American Spiders and Their Spinning-Work*, vol. ii, chap. xv, "Ancestral Spiders and Their Habits."

some signal from nature, some potent impulse or condition.

Setting aside, then, the completed cycle of maturity as the sole cause of this remarkable assembly, it is interesting and not improbable to suppose that a wave of sympathetic excitement issuing from a few nests may have infected all the surrounding section until, by a common impulse, the entire emmet population of the mountain-side was astir with the fever of flight. We know how, in human societies, neighboring families, towns, and cities are apt to be seized almost simultaneously with a political or patriotic or religious fervor, or revival, that spreads with a swiftness and completeness that are so remarkable as to appear to many quite beyond known causes. With equal celerity and universality, and equal mystery of psychological cause, will panics spread among armies and communities of our race.

Psychic contagions are not confined to men. The animal world, in some of its races, at least, is subject thereto; and to these, in some measure, we may attribute the impulse that seizes at once the myriads of winged ants, and sets them forth together. This impulse must be felt by the workers also, the rulers of the communes, if indeed it does not originate with them; for their dependents are not always willing exiles from the favored precincts of the home nest. I have seen them turning back at first with manifest reluctance, and seeking to enter the city gates against the ungentle persuasion of the workers' sharp mandibles. It requires such discipline and the allied mighty force of a natural instinct to banish them from their sheltered life of ease in their happy native homes.

It is appalling to think that upon the industrious workers devolves the task of providing food (Fig. 76), home quarters, and protection for the many millions of robust creatures that were overwhelmed in the waters of Lone-

Fig. 76—ARRIVAL OF THE FOOD-BEARERS AMONG THE WINGED DEPENDENTS

some Lake, together with the multitudes that must have escaped. And all this in addition to the nurture and care of an equal or even greater number of immature citizens in the form of eggs, larvæ, and pupæ! That

this is done, and done effectively, is a marvel of industry and devotion probably unsurpassed in the records of animal life.

Why is this service undertaken? What is the impelling force to such labors and sacrifice? The answer is not far to find. It is the inborn and ingrained instinct to preserve the species and the commune. For that ants live, and for that they die. Their life is ideally altruistic. Nature has so deeply fixed upon their organism the love of their own community and their own kind that there seems to be no room for mere selfish pleasure of any sort. The necessity to maintain by their labors the host of males and virgin queens raises no opposition, and apparently excites no ill will. It is a communal necessity. It is exacted by nature. That is enough—for an ant citizen.

I have never noticed in the working castes the faintest ripple of anger or rude treatment toward these adult dependents, suggestive of envy or of impatience under their heavy burdens, and reacting in violence. Their attitude is invariably helpful when help is needed, and tolerant and good-tempered at all times. Not until the crisis moment of the commune has come, when the great exodus of the sexes is to begin, is there any show of wish to be rid of their charges. And that is controlled by the same imperative spirit of altruism toward the future of the race, and has in it no trace of personal cruelty or hate.

Doubtless, in their brief and strenuous life, the pleasures of appetite have some place, although indulged with exemplary moderation. Theirs, too, must be the satisfaction of all normal healthy organisms in natural work and in the achievement of daily rounds of service. What

may be the depth or quality of such feelings in ants we may not know, but surely kindly nature has not denied some just measure thereof to these faithful and laborious creatures. But, as far as the observer can note, these are small factors in determining emmet behavior. And, withal, work is work, in an ant commune as elsewhere. Its burdens are often severe, its risks are great, and the number of workers daily maimed and slain in the course of duty is a heavy drain upon the vital resources of all such communities.

Yet, how diligently their task is wrought, how cheerfully, how patiently, how bravely, how well! Silent citizens of the ant city! With all his God-like endowments, man may well consider your ways herein as worthy models for his own relations to the commonwealth and the common weal. It may be true that all this admirable conduct is wrought without moral consciousness and free will, such as mark "articulate speaking men," undesignedly, instinctively, automatically, if you please. But there it is. And it is there by that Over-thought and Over-force who has appointed destiny and basal character for communes of ants as well as for cities of men. And by this bond and fellowship we may find a common ground for our admiration and for imitation.

We have seen that the first eggs laid by the ant queen are embryo workers. This follows necessarily from the fact that new communities arise from single fertile females. The existence and growth of the society require that its first members should be helpers and not dependents. Only when the pioneer colony is strong enough in workers to add to the needful conditions of ordinary life and growth the burden of supporting the males and females do these sexed forms appear.

The author has not noted in newly dropped eggs any marks indicative of differences between sex-eggs and caste-eggs, nor does he know of observations by other connoisseurs to that effect. If such exist they are of a subtle character and escape ordinary observation. But as the eggs develop into larvæ and begin to grow, they are easily separated into groups by their sizes, according to the nature of castes, in any specific nest. So, also, when the larvæ have spun themselves into their cocoons, the workers and the females issue from the large cocoons, and both appear with their own distinctive characters. There appears to be no seclusion of workers for special feeding and care in order to produce queens, as with bees. The larvæ lie in common heaps, and share, as far as can be noted, precisely the same amount of feeding and attention. The worker castes, as well as the males and females, show at once after emergence from the pupal stage their distinctive characteristics, not only in size, but in such a striking peculiarity as the unusual development of the head of the soldier caste in genera like Pheidole and Atta, although this is liable to much variation.

When the imago life is achieved, the radical difference between the sexes and the worker forms soon appears. The workers excel in complex instincts, and as they turn to their various duties as nurses, builders, miners, foragers, sentinels, warriors, sanitarians, etc., they display a plasticity of temperament that suggests the possession of marked qualities. These are much less apparent in the virgin queens, where, indeed, they scarcely appear. But after fecundation, deälation, and entrance upon nest-founding there is a rapid development of latent qualities into action which their important rôle requires.

On the other hand, the males are phenomenally stupid. They are unable to distinguish friends from foes, or to find their way back home when they wander from their nests. The points in which they are richly endowed are the eyes and antennæ, the two sense organs which are connected with the brain, and give that keenness of sight and smell required for their especial function in life—to possess themselves of the female during or before their nuptial flight.

Fig. 77—THE BRAINS OF ANTS
W—Worker. *F*—Female. *M*—Male. (After Forel.)

With these ethological facts closely corresponds the structure of the brain in the three forms that constitute an ant community. This has been admirably shown by Doctor Forel in his figures of the brains of the worker, queen and male of *Lasius fuliginosus* (Fig. 77). The brain is relatively large in the worker, the cortical portion extremely rich in cellular elements. It is much smaller in the female, and is almost vestigial in the male, although in the

latter the optic and olfactory lobes are large. [F. 5, p. 490.]

Life within the precincts of ant communes is largely hidden from the outside world. However, one may get fairly truthful glimpses thereof from studies of formicaries arranged in glass vessels. Many such, which were artificial only in their limited spheres and furnished food, for they were built up by the inmates wholly upon their own lines, have yielded the author numerous facts and hints from which he has pictured images of interior life that cannot be far from correct. Observations of actions on and around the nest exteriors, and analysis of the mounds themselves, have added to the accuracy of such inferences.

But much remains unknown, and we are left largely to conjecture in representing the life of the winged males and females that fill up the cavernous rooms and crowd the galleries of the Alleghany mound-makers and similar emmet architects. We can fancy the industrious workers passing from one to another among these throngs of winged dependents, feeding them from the liquid sweets stored within their crops during foraging trips. How eagerly are welcomed arrivals from the outer world, of these voyagers! And how zealously the incomers hasten to their task! A bevy of boarding-school boys could not give heartier greeting in their living-quarters to the latest arrival from home, laden with spoils of storeroom and kitchen, than they receive.

We see the crowding and the general stir as the food-bearers come round: the flutter of wings, the haste and hustling of greedy ones after undue portions, since even an ant-hill is not exempt from such traits, especially (one might almost say, exclusively) among the idlers.

We note the agitation that follows in the trail of the ministering ants as they push their way from point to point, until their exhausted supply warns them to retire from the scene.

What other pleasures than those of appetite are open to these winged dependents? The pleasure of work is denied them by nature. The natural history of social insects gives no examples of more absolute idlers than they. Does time hang heavy as they plunge through the galleries, jostled by the miners and builders, who pay little heed to them as they run to and fro with their burdens? In the domed chambers wherein they congregate, and the swelling bays that relieve the strain of traffic upon the galleries and gangways, they huddle and preen their coats and sleep, and in some species, perhaps, pay and receive sexual court. What other activities engage their attention in this listless life, in the midst of their strenuous supporters, it were vain further to conjecture. Future observers may have something more to tell.

Such a subterranean career is, from our standpoint, passed in darkness. But we are not to conclude that the same or even an analogous condition exists for our emmet cave-dwellers. There may reach them vibratory remnants of light-rays, in measure and quality quite beyond human appreciation, but which suffice for ants. Moreover, those remarkable olfactory organs, the antennæ, are so extended and flexible, so sensitive and so capable of conveying a knowledge of environing conditions and relations, that they may easily supplement or even supply the seeming deficiency of light.

Be that as it may, the writer, after the most careful attention of which he is capable, has never been able to

note, in any species, the slightest shock or shrinking when ants issue from their formicary gates into the sunlight, such as one would expect in beings organized after our human fashion. Of course, the passage through the vestibule of the gateway, where it exists, affords an opportunity (were such needed) to adapt the eye to such an extreme change. But in our mountain mound-builders, and other species of like habit, there is no measurable vestibule. Besides, the movements of the ants are so rapid that their plunge out of darkness into full light seems to be instantaneous. As all the varied labors of the workers are carried on within the subterranean passages and rooms without the least embarrassment, those places cannot be so cheerless to the winged idlers as one might fancy. Perhaps the monotony of their inactive career, in such sharp contrast with that of their protectors, may be the chief factor in their discomfort, if any such there be.

Breaks in the monotony of this underground life come to the virgin queens and males in occasional visits to the outer air. These were especially observed during studies of the agricultural ants of Texas, in the neighborhood of Austin. Such excursions were frequent, and were evidently made simply to enjoy a bit of sport in the sunshine (Fig. 78). Both sexes were seen bobbing in and out of the gates, peeping forth and quickly withdrawing, and again venturing one or two feet distant from the entrance upon the smooth disk that surrounds it. However, they rarely went far beyond the gate, and were quick to retire within at any sound or suspicion of danger. [McC. 3, p. 141.]

One female reached a grass-stalk near the pavement's edge, and amused herself by swinging upon the blade.

On the broad plaza of one city half a dozen or more young queens were out at the same time. Their play took the form of running up a large pebble near the gate, facing the wind, rising to a rampant posture, and so down again. Several having ascended the stone at one time, there ensued a playful passage-at-arms for position.

Fig. 78—WINGED FEMALE ANTS AT PLAY ON THE PLAZA

They nipped one another gently with their mandibles, and chased one another from favorite spots. Their whole demeanor was that of a party of romping youth playing "tag" or "hold the fort" upon a big rock. [McC. 7, pp. 4, 22.]

While the young queens lightly nipped one another in

their game, as dogs at play will do, it was noticed that they never took such liberty with the workers. The latter evidently kept close watch upon the sporting princesses. They occasionally saluted them with their antennæ in the usual way, or touched them at the abdomen, but did not interfere with the sport. Their attitude reminded one of that of an under-teacher, or usher, charged with the duty of conducting, or overseeing a bevy of seminary girls in their daily exercise in the open air.

In order to test the strictness of this watch, one of the group was thrown, by a quick motion of the hand, from the vicinage of the gate to the verge of the plaza. She was instantly surrounded by several workers, who began a determined effort to control her action, trying to compel her to return toward the gate. The queenling was confused or stubborn, and opposed her strength quite vigorously to the purpose of the guard. For some time the party floundered among the stumps of grass-stalks in the little clearing on the margin of the plaza, the bulky form of the one stubbornly set against the quiet persistence of the others. It was noticeable that the guards carefully abstained from anything like hurtful violence to their charge, and that she did not attempt to escape by flight. The issue of this trial of will-power was not determined, for the refractory queenling was needed as a specimen.

It is perhaps worth noting that the worker castes were never seen at play. If records have been made by other observers of such light behavior on their part, the author has not noted them. The truth seems to be that their life is so strenuous from its first experiences of imago-hood to the end of their career, that there is no time for

recreations of any sort. Work! work! ceaseless work on their endless round of duty is their lot, varied only by scant periods for eating, for sleep, for personal cleansing, and occasional mutual "shampooing." The amusements of ant communities, such as they are, are limited to the dependent leisure classes. However, it must be remembered that all of the routine labor is not of the exacting sort, like mining and nursing. Moreover, as we have seen, the liberty to "knock off work" at will is one of the inalienable privileges of the workers—one that is freely used, but apparently never abused. No doubt, under such a rule, they get more satisfaction—one might even say more enjoyment—out of life than winged idlers whose career is shut in and restricted at so many points that they seem to be little more than privileged prisoners of state.

CHAPTER X

WARRIOR ANTS, AND THEIR EQUIPMENT FOR WAR

WAR, it is said, is a brutal way of settling differences among men. That is true; and therein lies the fact which gives most serious pause to one who would study the subject philosophically, with an outlook upon nature at large. War *is* brutal—a natural habit of brutes, and of the whole realm of organized life below them, that wage war upon one another instinctively. Their natural life is one of endless conflict. They who justify war do so on the ground of its universal prevalence among creatures in a state of nature. It is brutal but natural, and man, being of nature, has his physical kinships with brutes and their lower allies.

Doubtless those who base their opposition to war on the divine precepts of the Prince of Peace have here no difficulty. They admit the premise, but claim that Jesus Christ, whose laws they obey, came to abrogate the evil in the old, and to establish a new and spiritual kingdom in Nature. He brought into human discipline a new development, a higher stage of life, wherein war is a discordant element. This is the new Nature, the spiritual kingdom. It is the dawn of an ever-deepening Day after a birth-Night wherein wild things ruled, but Life and Light were born. The spiritual man, not the natural, is now supreme, and under Christ the nations are to learn war no more.

The writer accepts this view. He has had personal experience in two wars—the American Civil War and the Spanish-American, in Cuba. He knows well its worst features and its best. He believes that universal peace and fraternity ought to be the ultimate aim of our race, and that armies and navies are justified simply as national police forces for the administration of those benevolent functions for which governments should exist among men. Nevertheless, he recognizes that to many minds the force of the facts, as seen in nature, is not readily put aside; and that the universal war habit of organized beings, as it appears to have existed in all time, seems to place upon a higher plane, as in harmony with natural laws, those war-like habits and acts that have dominated human history. This, at least, gives an exceptional interest to a study, for the sake of comparison, of the war methods of those lower orders of living beings whose social organizations strongly suggest our own.

Among the foremost of these are ants, and ants, as an order, are war-like insects. The foragers carry their natural pugnacity into the field as isolated individuals, and show decided courage in the quest of food. Therein they are freebooters. Whatever falls in their way and they are able to possess, they take. This, as in the case of human brigands, often requires an appeal to force. An ant commune is as fair a scene of peaceful industry as a beehive; but everywhere in its vicinage "doth dogged war bristle his angry crest, and snarleth in the gentle eyes of peace."

This readiness for hostilities and ferocity in attack have been noted and recorded often of the hosts of true ants that swarm along the pathways of travellers in the tropics. For example, Stanley speaks of the

"belligerent warriors" among the innumerable species of various colors that filled the African forests; of the "hot-water ants," as his men not inaptly named them, from the smarting pain of their stings; and of the minute red ants that everywhere covered the forest leaves and attacked his pioneers so viciously that their backs were soon blistered. These creatures doubtless acted from a principle of self-defence that led them to hurl their fighting myriads upon everything that crossed their way and disturbed their solitudes, though with no hostile intent. It was an act of natural belligerency, and no doubt was protective, in the aggregate, of life. It certainly seemed as little reasonable as were the unprovoked attacks of the human hordes of cannibal savages that assailed his expedition in their crowded boats, as he made his way through the heart of the Dark Continent, along the mighty Livingstone River. The tribes of ants and the tribes of men were not unlike in the native combativeness that animated them. [St. vol. ii, pp. 138, 225.]

The woods within whose open spaces the mound-making ants rear their conical cities are also hospitable to the carpenter ants (*Camponotus pennsylvanicus*), and the two species are natural enemies. Wherever they chance to meet a combat is inevitable, in which numbers sometimes become involved, and always death and wounds succeed. Should one of these errant Camponoti, from a near-by nest in a white-oak tree, chance to cross a mound-builder's bounds, its tread, light as it is, affects the commune like a signal-shot or a fire-alarm. From the nearest gates issue squads of sentinels, who fling themselves in mass upon the intruder. Flight is thus hindered, even if it were considered, and,

despite the overwhelming odds, Camponotus joins battle, and only succumbs, and is dragged within the walls, after a number of its assailants have been maimed or slain.

The agitation in such a case is limited to a narrow sphere, for somehow the commune knows that the danger is merely local. Therefore, outside of that circle, the various duties of the government go quietly on. But it is a notable feature of this commune that upon a general alarm the whole citizenship rises up to meet the threatening peril. Many times in many ways has the author tested this. A few pats of the foot or strokes of a stick upon the surface would call out a host of sentinels and workers. The interior construction of the mound is well adapted to communicate sound or vibratory movements rapidly. Through the conical mass of intercommunicating galleries and rooms the agitation at the surface appeared to be quickly carried to all parts of the mound.

At all events, it reached enough to call out, almost instantaneously, a multitude of insects. With antennæ erect and quivering, with abdomens well raised from the ground, with legs ajerk and heads aloft, they circled about and rushed to and fro, their whole mien showing keen excitement. With them, assuredly, "the toil of war" is "a pain that only seems to seek out danger." It is not a question of who has made the attack, or why made, or whether one or another should come to the rescue. At once the republic is ready to launch forth its entire force, if need be, against real or imaginary foes. This perfect unison in resisting the assault of an enemy is surely an element of civic strength and permanence. During my boyhood a saying of one of our naval heroes was widely current, and was a theme for

discussion in some of our Ohio debating societies: "My country: may she always be right; but, right or wrong, my country!" No budding ant citizen would need to debate that question. The commune with ants always has absolute priority with all its citizens. Their supreme law is its demands, for life or for death.

History and, indeed, our own observation have shown among men examples of somewhat smiliar communal unison under the impulse of great social movements. A wave of patriotic feeling will sweep over city or State or nation, and carry it swiftly along until the purpose or sentiment or emotion that inspired the movement shall be spent in achievement or hopeless failure. Such movements are more unanimous, and so more harmonious, in ant than in human communes. There is absolute good temper and unanimity of feeling among the myriads of inhabitants of our emmet mound city in all movements noted, whether peaceful or warlike. Of course, one does not expect such complete fraternity among men, even in far less widely extended citizenships. Whether in this the bipeds or the sexipeds are better off and nearer to nature, let the reader query. If one were to indulge such a fancy as that human civics have developed from such lower and simpler forms as ants exhibit, it would seem that in the evolution they have been carried a long way (in some respects) from the original type.

No trait in emmet character is more interesting than this entire devotion of every individual, even unto death, to the welfare of the community. The uprising of a threatened ant city is a remarkable exhibition. The peaceful commune is instantly transformed into an armed camp. There is not the slightest delay or hesitation in

the response. With utter abandon the little creatures hurl themselves upon their assailants. No question seems to arise: Shall we abstain? Shall we retreat?

> "Or shall we on the helmet of our foes
> Tell our devotion with revengeful arms?"

No condition of size or character in the adversary has the least influence upon their action. There is no trace of personal fear, no regard for life, no balancing of probabilities as to victory or defeat, but with the most formidable as with the feeblest enemy the ants join eager issue. There is no "melangering." None hangs back waiting for others to take the brunt of battle. In our mound-making ants, cowardice is an unknown vice. I do not recall a clear case of poltroonery. They are as valiant as they are industrious. In many cases the destruction of the defenders is foregone, and the foremost in the column are certain to perish. That may not be understood by them; but were it so, it would not make any difference with these citizen warriors, with whom labor, health, unlimited service—life itself—are held as the unreserved heritage of the commune.

There have been times in the history of human commonwealths when a large portion of the citizenships reached as high a standard of patriotism. At all times there are some who, in the surrender of their substance, their service, themselves, and—yet higher sacrifice—their sons to the nation, show like devotion. But history would surely falter if challenged to find among men a case of unanimity in devotion to the commune in time of danger equal to that of the mound-making ants of the Alleghanies.

A good example of the pugnacity and courage of ants

is a small species (*Dorymyrmex flavus*), that digs its little nests upon the great open spaces surrounding the central mound of the occident ant of Colorado. A large commune of the latter which had been badly damaged by the wash of heavy rains was a scene of active rebuilding. Four moundlets of Dorymyrmex had been reared upon the pavement, one of them quite near a centre of operations in one of the main tracks by which the workers had ingress and egress. Here an incessant warfare was being waged by the dwarfs upon their big neighbors. Every occident that essayed the passage to or from the ground was attacked. Squads of Dorymyrmex surrounded their single gate, and on the approach of one of the occidents the nearest warrior flung herself upon the unconscious intruder. That she was alone, that there was such disparity in size between her and her adversary were facts that plainly had no part in her calculations.

Fig. 79—WAR-LIKE DWARFS ATTACKING AN OCCIDENT ANT

It was curious to note the effect upon Occidentalis. She stopped instantly; drew her feet closer together; stiffened the legs, thus raising her body well above the earth; bowed her back; elevated her head; stretched out the sensitive antennæ, as though to guard them especially from harm; opened the mandibles; and, in fact, presented an amusing likeness to the pose of a cat at the

first onset of a dog. The fore leg upon which Dorymyrmex had seized, and which had instantly been raised, was then shaken violently, and the little assailant rolled upon the ground (Fig. 80).

Thereupon occident unbent herself and resumed her way. She scarcely had started ere her tormentor

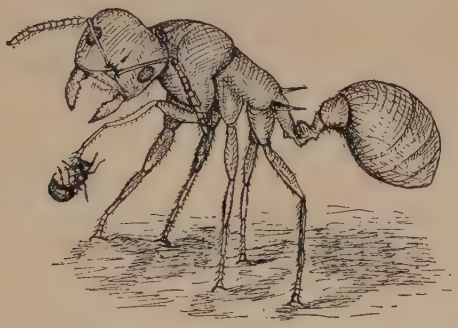


Fig. 80—A PLUCKY LILIPUTIAN ATTACKING AN OCCIDENT ANT

again was upon her, followed by another and another, until her body was dotted with the little vixens. They grasped her feet, fastened upon the under parts of the abdomen, mounted her back, seized her antennæ. They could not be shaken off. She snapped at them with her strong jaws; struck at them with her claws; doubled her abdomen under her body, and thrust at them her barbed sting. Some were crushed, some were thrown off, but others came to the assault. Anon the warring mass rolled upon the ground, a whirling ball of red and dark yellow, of quivering legs and antennæ. At last the aggressors were driven off, or released their hold, and occident retired to a safe distance, combed her ruffled hair, and passed by on the other side (Fig. 79).

Some of the occidents, as soon as they neared the

Dorymyrmex bounds, paused, and stood quite still, as though reconnoitring the hostile quarters. The pause was fatal, for they were attacked at once by the vigilant sentinels, who sallied forth to a goodly distance upon the avenue. Others seemed to recognize that discretion is the better part of valor, and made a wide dètour of the skirmish line of the little vixenish raiders. It was plain that the occidents thoroughly knew the qualities and temper of their involuntary guests, and regarded them with wholesome distrust, not to say fear.

The result of the guerilla warfare above described was rather remarkable. The next morning, upon visiting the ground, I found that the occidents had abandoned their old avenue, had cut down and around the Dorymyrmex colony, and made an opening on the edge of a slight ridge several inches beyond the disputed territory, but still in the line of the avenue they had been using. A little of the pains required for this last would have cut out and carried away the whole Dorymyrmex nest space, whose contingent of diminutive warriors could have been overwhelmed in a moment by the legions of their huge hosts. Subsequently the occidents made an amusing retaliation upon their wee tormentors, for I found their nest literally buried under the dirt excavated from the new gangway, and dumped upon their gate and moundlet. It was a fitting and laughable punishment for the little churls, who, however, would probably cut their way out, unless the process were continued.

These incidents will suffice to show that courage is a general characteristic of ants. But one finds herein the same temperamental differences that mark the tribes of men. As there are nations justly described as war-

like, and others as peaceful, so among ants there are species whose natural disposition is bold, fierce, combative, and species that, in comparison, are timid and unwarlike. An apt illustration of this is given by Professor Wheeler [W. 1, p. 527], who found lodged in the leaves of a Mexican tillandsia, colonies of ants of several different species. They seemed to be living on good terms with one another, but were not so complacent toward their human observer. While tearing the leaves asunder the little Cremastogasters (*brevispinosa*) attacked him vigorously, though their lilliputian stings and mandibles hardly got through his outer skin. But the huge *Camponotus abdominalis* rushed out in a body, and the powerful jaws of the soldiers, reinforced by the copious formic acid batteries of the whole company, compelled him to give up his investigations. Two species of the grotesque genus Cryptocerus were as gentle as lambs, resting quietly on his hands and clothing. A group of timid little *Leptothorax petiolatus* took to their legs; while the superb, wasp-like Pseudomyrmas (*gracilis*) made dashes at the investigator from among their glistening larvæ and pupæ, but hastened back, as if afraid to leave their young. Here, at one view, could be noted the differences in natural combativeness which one sees among creatures of a larger sort.

Professor Forel, during his visit to the United States, observed a small troop of sanguine ants attack a community of *Formica subsericea*. At the mere assault the latter betook themselves to flight, carrying their larvæ and pupæ. [F. 6.] Even these they permitted the slave-making marauders to snatch away without serious resistance. In all his extensive and varied experience, Forel had not seen such complete and absurd

cowardice. And yet the Subsericeas observed by me—and there are numerous colonies on my own country place—while they are not conspicuous for warlikeness, are quite normal in their general courageousness. But there are no slave-making species in their vicinage. Their spirit has not been cowed through successive conquests by stronger and fiercer foes (Fig. 81). They are, therefore, not open to that strange seizure which may beset ants as well as men, even the stoutest-hearted men, known as a panic.

With ants, too, as with men, circumstances influence both personal and communal courage. *Formica fusca*,

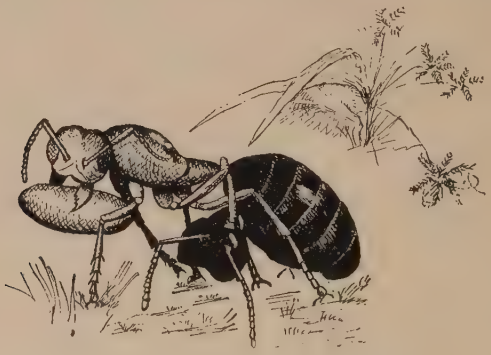


Fig. 81—SLAVE-HOLDING ANT

Going home with a plundered cocoon and a dissevered head of an ant clinging to leg

one of the favorite auxiliaries or so-called slaves of the sanguine slave-makers, has been observed by Wassmann and Forel to be more courageous with them than when nesting alone. Backed up by their redoubtable leaders and associates, they act as do men under similar circumstances, and stand to their weapons when otherwise they would retreat. Independent of other and tactical

considerations, military men know the value of "reserves" in bracing up the troops on the firing-line by an appeal to the confidence that springs from consciousness of an efficient support to fall back upon. It is curious to note an experience somewhat like this in the above reflex as operative among ants.

Naturally our thoughts, when turned to the subject of war, call up the forms of males as the sole or chief actors. So it is among men and the wild and domestic animals that we know best. Certainly there are women not lacking in belligerency, and when congregated in riotous mobs they have at times been fiercely combative. But in organized and communal fighting females rarely have had a part. War is a male occupation.

In ant communes we strike another atmosphere. The difference between the male temperament in ants and in the human species is so great that we cannot frame a just basis for comparison. In man the masterful qualities have developed in the male and the dependent ones in the female. It is the reverse of this among ants. The male is a dependent, in whom capability of self-support and self-defence has been obliterated. The female—and it must be remembered that all workers are females in a stage of incomplete development—is the sole efficient servitor of the commune in peace and in war.

The queen, or productive female, is The Commune in germ. She is The Ant, in whom are centred all the qualities and functions of the whole race, save the power to quicken the eggs. She is the true "war lord" in the early stages of establishing a nation, and only when the foundations are securely fixed does she abdicate, and, effacing herself as a chief, retire from the toils and ex-

posures of leadership, and give herself up to the duty of adding to the communal numbers, in and for which she is sheltered and protected by the force of the entire commune.

Her original offices as builder, purveyor, caretaker, defender, pass over to the workers, and therewith the war-like spirit which communal safety requires. When the young males come upon the scene they are treasured for their one necessary function, and then cast off. They are not specialized as soldiers; nature has forbidden that by denying them defensive weapons; for a like reason they cannot work. They are simply dependents—nature's *beau ideal* of the "gentleman loafer." Thus it comes about that all emmet warriors are veritable Amazons.

It has been said that an ant commune presents the phenomenon of a social government where every active citizen—or "citizeness," if one fancies that term—is a warrior. Yet herein, also, we may record an exception that approximates them more closely to our own conception of a military organization wherein the fighting members are a separate class. One might use a stronger word; for in the course of human history soldiers have been not rarely a real caste. And, in truth, it amounts to that even now in some nations. Perhaps the "anti-militarism" that marks social agitations in certain quarters is simply a modern industrial swing away from the old bondage to a soldier caste.

Be that as it may, nature shows us in ant communes examples, in various stages of development, of the differentiation of ordinary workers into soldiers. In many species the line of demarcation is not sharply drawn, but appears in the greater size, especially of the head

and jaws, the important parts in attack and defence. But in other species the process has advanced to a distinct soldier caste whose characteristics are most decided.

In the genus Pheidole we have species in which the functions of workers and soldiers are clearly separate. Of a Texas species, *Pheidole instabilis*, the workers alone, though of comparatively diminutive size, manage the colony's affairs. They forage for seeds or dead insects, which they drag to the nest. They dig out the galleries, carry about and tend the larvæ and pupæ, even the huge female ones, and assist to cut out the callows from their pupal envelopes. On the other hand, the soldiers have an office for which their abnormally large heads and strong jaws peculiarly fit them: they are the guardians of the nest. They form a sentinel cordon around the young brood and the callow antlings. They are stolid and inactive, keepers at home, but eschew the task of tending the communal babies. Their heads are so large proportionately to their bodies, that if turned upon their backs they are often unable to right themselves, and if not relieved may die practically standing on their heads.

This big-headedness, with its corresponding development of the jaws, however, has led to a peculiar service. The soldiers act as the communal carvers or trenchers, and crack the shells of the oily seeds and the tough, chitinous cases of the insects which the foragers collect for the commissary department (see chap. iv). Somewhat oddly, they abstain from levying toll upon the food supplies thus made ready for general use, but draw their rations directly from the comminuted stock in the workers' crops. [W. 6, p. 4.]

This genus has representatives in the Eastern United States—*Pheidole pennsylvanicus* and *Ph. megacephala.* The author has made some notes of the habits and nest architecture of the former in his studies of the occident ant. [McC. 4, p. 149.] As it is a harvesting ant, the

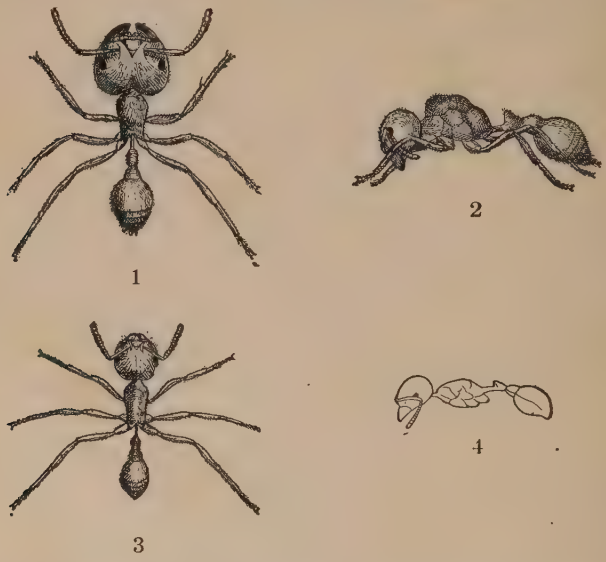


Fig. 82—THE FLORIDA HARVESTER (POGONOMYRMEX CRUDELIS)
1. Soldier worker. 2. Unwinged queen. 3. Worker major. 4. Worker minor.

massive heads of the soldiers may be utilized for the same service as those of *P. instabilis.* Another ant, the Florida harvester, *Pogonomyrmex crudelis* (Fig. 82), which garners seeds, has large-headed soldiers, which perhaps may be found also to unite the function of policemen with that of trenchers. [McC. 3, pl. IX, Fig. 41.]

The genus Atta contributes examples of species provided with soldiers with exaggerated cephalic enlarge-

ment. In a Texas species, *Atta fervens*, the duties of these soldiers appear to have been specialized until they are as distinct as are their forms. This species is the well-known cutting or parasol ant of Texas, whose defoliation of trees, for the enrichment of their cavernous "mushroom gardens," makes them a decided pest to farmers. In my studies of their habits it was noted that during their foraging excursions the vast columns of leaf-cutters and carriers were marshalled by the big-headed soldiers. Both on the raid and on the return they accompanied the marching ranks, appearing to take no part in the actual work of the expedition, but moving back and forth along the flanks, after the fashion of scouts and pioneers, or of an official guard and escort. [McC. 10, p. 36.]

Other examples might be cited,[1] but the above sufficiently illustrate the fact that in the military government of ant communes we meet with a feature analogous to that well-known characteristic of human societies: the differentiation of the functions of police and defence into a special class, or caste, known as soldiers and sailors.

How far in this natural arrangement the industrial element among the ant citizens is dominated by the soldiers is not known—at least, to the present writer. Within certain lines—as, for example, submission to their soldier escort by the leaf-cutters of *Atta fervens*—they permit the exercise of legitimate authority. But they seem able to control the situation when so inclined. Professor Wheeler has seen the workers of *Camponotus ferrugineus* kill and dismember their soldiers in a case

[1] A remarkable case is that of Polyergus, which is referred to in chap. xiv—"The Founding of Slave-Making Ant Communes."

where the food supply of the commune had become insufficient. They thus at once showed that their guards were not their masters, and that workers held the first rank in their social order, though of course they incidentally demonstrated their lack of anything like "the quality of mercy" in their relations to their associates. In short, we may conclude, with reasonable assurance, that the government of ant communes is not a military despotism, and that soldiers, when specially differentiated, are simply a co-ordinate and subordinate part of the social organization.

The weapons (Fig. 83) with which ants carry on their wars are placed at the extremities of the body. A pair

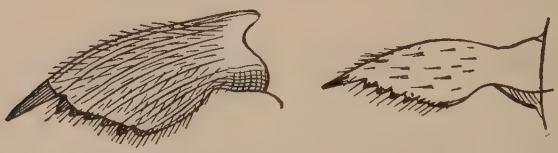


Fig. 83—MANDIBLES WHICH ARE USED AS WEAPONS BY WORKERS OF AGRICULTURAL ANTS

of movable jaws, or mandibles, are attached by strong muscles to the face. They are palmate, toothed along the receding edges, terminating on the inside margin in a large pointed tooth or tusk. These two opposed instruments, working against each other, form the composite tool and war-weapon of ants. With these they dig their galleries in the earth, or carve them out of wood, cut down grass, defoliate trees, seize and cut up food of all sorts. Being palm-shaped as a rule, the gathered and comminuted material can be compressed into their hollows, and so carried as conveniently as in a basket or barrow. As the muscles permit the application of much or little force at the insect's will, the mandibles can be

clamped together with power enough to break and tear tough fibres, or approximated so gently that the soft eggs and tender larvæ can be borne about as daintily as an infant in a mother's arms. Thus they aptly combine some of the qualities of the human hand with those of a beast's jaws.

It is this instrument—for the two mandibles work together as one organ—that serves ants effectively as the chief weapon in their various combats; it is at once war-club, battle-axe, and sword; it will decapitate a foe with the facility of a sabre or guillotine, will sever a leg or antenna as deftly as a scimetar, or crush a skull in its formidable vise as would tomahawk or club. It is terrible to see, in the fierce encounter of emmet warriors, the cruel havoc wrought by this implement.

As effective, perhaps, and fatal, but less apparent in its operation, is the weapon attached to the opposite

Fig. 84—USING THE STING IN FLIGHT
Occident ant in duel with fetid ant. A comrade occident looks complacently on

extremity. Enclosed within the vertex of the abdomen is an arrangement of organs known as the sting (Fig. 84). In one great division of the ant genera these are veritable stinging organs, like those of bees and wasps.

For example, in the agricultural ant, in which the author has studied them most carefully, they consist of the poison gland and sac, the accessory organ or oil sac, and the stinging apparatus. These are all situated in the lower portion of the apex of the abdomen, close to the ventral surface, and are covered by the final ventral plates.

The word "sting" as commonly used cannot be applied to any one organ, but expresses rather a combination of three organs, one of which, the sting-case, is single; the others, the stinging-prickles and the out-sheath which encloses them, are double. They are supported within the apex of the abdomen, and are operated by a most ingenious system of levers and muscles. The sting-case is somewhat curved toward its chiselled point, which resembles a carpenter's gouge. In the act of stinging this gouge makes the first incision.

The two shafts of the stinging-prickles in repose are contained within the sting-case, but are thrust out alternately when the ant stings, entering the wound made by the gouge, aggravating it, and injecting the poison. The prickles are slender, sharp, hollow triangular chitinous rods with barbed points. The posterior parts, or shafts, which lie alongside each other within the sting-case, are straight below, but at the top, or anterior part, are bent away from each other, forming the bows. Each stinging-prickle thus consists of a shaft and bow which, as operated in action, serves the purpose of a spear, or lance, and bow and arrow. The force of human muscles by which the ancient artillery was made effective has its analogue in the protruder and retractor muscles of the ant, attached to the bow of the prickles, by which the shafts, with their pair of six-barbed needles, are forced out and drawn back.

The above forms substantially what is the piercing mechanism of the harvesting ant's sting.[1] But the ant warrior does not depend upon the simple thrust of its lance to place its antagonist out of action. The poisoned arrows and the chemical projectiles of human warriors have also their representatives in the equipment of emmet soldiers. Situated above the stinging mechanism, and communicating therewith by a conduit, is the poison sac with its included gland. Herein is secreted a virulent acid which, being forced by muscular pressure into the hollow prickles, is carried down and into the incision made by the point, perhaps through an orifice in the barbs.

Associated with this is the accessory organ or oil sac, located also just above the sting-bow. Its duct, through which issues an oily secretion, enters the throat of the sting-case close beside the opening of the conduit of the poison sac. Both ducts pass for some distance into the case, separated only by a delicate chitinous fold, finally to terminate together. The oily secretion, mingling with the acid poison, probably tends to distribute it over a larger surface, with corresponding ability to injure; and may add to its power to adhere to and penetrate the attacked surface. Perhaps, also, it serves as a lubricant to the sting.

In a large number of ant genera, including many with which we are most familiar, as Formica, Lasius, and Camponotus, the stinging organs are rudimentary; that is, they are without the sting proper. They have no lance or arrow to thrust into their foes. Their stinging

[1] A more detailed description would be out of place here, but special students will find a complete histological description in the author's *Agricultural Ant of Texas*, pp. 171–192 and plates.

organs, otherwise complete, are operated as acid batteries from which shoot out poison streams. These enter the system of antagonists by the joints of limbs or other unarmored parts, and produce paralysis and death. Camponotus will eject this formic acid in such quantities as to be visible to the naked eye. When large numbers of the Alleghany Mountain mound-makers are irritated and given some object to attack, the fumes of the strong acid emissions are soon perceived. Lord Avebury found, after disturbing the nest of a species of Formica in Switzerland, that a hand held as much as ten inches above the ants was covered with acid. Their mode of punishing a human victim is to scrape away the outer skin with their mandibles and eject their poison upon the abrasion, which causes a painful smart. In combat they drench their adversaries from these formidable acid batteries. Thus ants are effectively equipped for both defensive and aggressive war.

CHAPTER XI

HOW ANTS CARRY ON WAR

NO living creatures known to the writer so closely resemble man in the tendency to wage pitched battles as do ants. Vast numbers of separate species, or of hostile factions of the same species, may be seen massed in combat, which is continued for hours, days, or, in at least one case noted, for over a week. Some of the most extensive battles observed have been fought between neighboring communes of *Tetramorium cæspitum*, a small dark-brown species common to America and Europe. It abounds in and around Philadelphia, where it is popularly known as the "pavement ant," on account of its habit of making its nest under the bricks and flags of sidewalks.

I have often seen them engaged upon the large paving-flags that cover the walk from the manse through the grassy terrace fronting the church at Chestnut and Thirty-seventh Street. They fairly blackened considerable spaces of the gray stones with the vast numbers of the combatants. Some details of one of these fights will give a fair type of all. In the centre the warriors were heaped several ranks high. The mass seemed to boil with the intensity of the action. There was no appearance of orderly array or "line of battle" formation. It was literally a mêlée, recalling descriptions of

battles in the days of chivalry, when armored warriors fought hand to hand.

From the central mass the numbers gradually diminished until, as spaces opened in the surrounding fringe of the fight, one could see small groups of combatants scattered over several square feet of surface. Most of them were duels; but trios, quartets, quintets abounded. In one case six ants were engaged with one; in the centre, two were tugging with interlocked mandibles, and five others were grouped around, like spokes in a wheel, each sawing or pulling at a limb of the unfortunate central integer, who was being torn to pieces. Here and there a larger group would be piled upon one another, heaving, pushing, tugging, like the athletes of a football rush, but with mortal intent.

The duellists seized each other by the head, frequently interclasping mandibles, and pulling backward or swaying back and forth. It was literally a "tug of war." Again, one would have her antagonist grasped by the face above the mandibles, which placed the latter at a great disadvantage. In such and other cases both ants would often be reared upon the hind and middle legs, with abdomens turned under and stinging organs out-thrust, making vicious stabs at one another.

All over the field disengaged ants were running about, excitedly seeking a foeman, incessantly stopping to challenge with antennæ, then hastening on until a hostile party was met, when at once the two locked mandibles and fell to. Many ran to and fro, stopping now at one group, now at another, to nip an abdomen, gnaw a leg, or snap at face or antennæ, and then would rush away to some more promising service.

Meantime, from the gates of the warring communes

—small openings on the edge of the paved walk—two streams of recruits were pouring toward the scene of strife. Their bodies fairly quivered under the intensity of their emotion as they ran along, reminding one of human crowds hurrying to a fire or a fight. As the two opposing streams met and intermingled, ant tackled ant in deathly grapple, and thus the fury of the battle was fed.

Of one party, distinguished as "Alpha," a long file of warriors was running from the field along the trail to the home nest. They challenged briefly every passing fellow, and pushed on. I conceived, as a solution of this conduct, that this was a file of messengers bearing from the field an appeal for recruits. They certainly were not running away. All appearances and all experience were against that inference. At all events, the ideas of a recruiting detail, a call for relief, fell in with the analogy of a human battle-field so strongly suggested by the scene before me.

From the central point of the fight, as first seen at the edge of the walk nearest the "Alphas," the vortex of the combat gradually shifted toward the gate of their antagonists, the "Gammas." At first it seemed as though that army were being slowly pushed from the field. But if so, the tide of battle afterward turned; for victory finally remained with them, as far as it could be adjudged to either party. At this period the field of battle was spread over a space two feet long by six inches wide, the fighters grouped most thickly about two centres, beyond and around which the walk was dotted with many duellists and small contending groups.

At 12.30 P.M. the battle, which had begun at 8.30 A.M., was practically over. The "rear guard" of the Alphas

were continually dropping into their home trail, and numbers of Gammas were filing to their gate in a sluggish way. Not a recruit from either side was coming to the field. The dead lay in little windrows where the tide of battle had left them, or whither they had crawled to die, or the rising breeze had borne them. Here and there among them were ants still living but fatally hurt, struggling to drag their mutilated bodies from the mass. Even so, two enemies, when forced together in this grim fellowship, would grip one another and roll and strain, giving their waning strength to a last hostile tug.

It was a not inapt reminder of after-battle scenes among men. Only, there was no hospital corps separating the dead and bearing off the wounded; no surgeons plying their ministry of bodily help and repair, nor chaplains their ministry of spiritual consolation. Dead, dying, and wounded were all alike abandoned by their late comrades, a number of whom, on both sides, were now gathered around the pats of butter and sugar which I had vainly placed in hope to lure them from fighting. The refection which they refused during the heat of combat was eagerly accepted to refresh themselves after the toils of strife. That, too, was a quite human-like scene, for soldiers must eat and drink when the dreadful stress of battle is eased. However, there was no attempt by the living ants to feed upon the dead, as one sees under other conditions.

The state of the wounded was pitiful, an exhibit in miniature of the dreadful aftermath of human battles. For example, here was a warrior whose middle leg on one side was sound, the hind leg cut off at the thigh, the front leg at the trochanter—a mere stump. On the opposite side the hind and middle legs retained all the

parts, but were broken, curved, useless, like paralyzed limbs, the joint effect of its enemies' mandibles and acid batteries. Its antennæ were both paralyzed, bent up, and motionless. It was thus bereft of all sense of direction, and all power of communication and progressive motion. It lifted up its head again and again in vain efforts to rise. It shook its stumps of legs, rolled upon its side, rested a moment, and then with ruling passion of emmet tidiness, strong even in death, struggled to support itself upon its abdomen, and tried to cleanse (perhaps to heal) with its tongue a fore leg.

Its adversary had not a whole leg left, its most perfect one being a middle leg that had lost the foot. All the others were torn off to the thigh, or the tibia, or close to the body, and one antenna was gone. There the two foes floundered close together, dismembered and dying, left to their fate by the comrades who had mutually helped in the achievement of this great victory. Like examples were scattered over the field, from which the rage of conflict had died away, except as it lingered here and there in duels or small groups of combatants doggedly fighting out their controversy to the death.

From time to time various groups had been removed from the mass, and placed in artificial nests prepared with a view to special experiments. Among these was a pair whose fate I wished to follow separately. One ant, that seemed to be quite sound, was interlocked with an antagonist much damaged, having lost several legs and an antenna. But it had tightly gripped in its jaws a leg of its adversary, who snapped at its antagonist's neck and face, and squirmed and doubled, and strove, with many contortions but in vain, to disable its opponent and get free.

As it promised to be a long engagement, I left them alone in their box and turned to view the battle. When I next saw the pair the duel was finished. The maimed warrior lay dead and near by the victor was seated upon a pebble nonchalantly preening her ruffled coat, and with comb and tongue and spined limbs was repairing the damage of battle.

I placed her near the Gamma gate, wishing to see if she could find her way home, and what would be her conduct and reception. She ran about in an involved path for nearly fifteen minutes, covering a great space, and at last fell upon the regular trail to the nest used by the ants of that commune. But as she showed no familiarity with the field, I concluded that she belonged elsewhere, and transferred her to the vicinage of gate Beta, one of the outlets in the territory of the Alpha colony.

She circled around in an irregular course, always drawing a little nearer to Beta. In her march she met a pair of combatants, exchanged antennal salutations, and passed on. Presently she came upon another duel, again challenged, and again passed on. She acted as if lost, but kept bearing gradually toward Alpha gate. Now she met several scouts who challenged her with some evident doubt as to her status, but let her go. Next she was stopped by a group with whom, plainly enough, was exchanged a satisfactory password and "How d'e do!" and then she was off with a joyous trot. She had struck the home trail! In a moment she dived into the gate. Home at last—home from the wars! Doubtless there may have been, on her part, a passing satisfaction like that which Burns sang in *The Soldier's Return:*

"When wild war's deadly blast was blawn,
An' gentle peace returning,
Wi' mony a sweet babe fatherless,
An' mony a widow mourning."

But we may be sure it was but a fleeting emotion, and that on the part of the commune there was neither for her nor for any other returning braves a civic demonstration of "Welcome home from war." They glided simply and naturally, as though from a night's rest, into the regular routine of communal duty, and there was no more to-do about it. Every active member of society stood ready to take the same risk, do the same service, make the same sacrifice. What occasion was there for special hero-mongering?

Verily; and when human commonwealths have reached the same level of patriotism and civil devotion, citizens may fairly take a like attitude. But until then gratitude for and due recognition of true heroism in army and navy must be held as a civic virtue, and the poet's, admonition be in place:

"The brave, poor soldier ne'er despise,
Nor count him for a stranger;
Remember, he's his country's stay
In day and hour of danger."

What was the cause of these conflicts between insects that apparently ought to have been close friends? In at least one case noted the quarrel clearly arose over a find of rations. The centre of the warring mass was some fatty matter which had been thrown on and around the seams of a brick pavement through which a large formicary had cut its gates. From the battle-field a column of Tetramoriums three or four lines deep stretched

along a depression made by a shallow surface drain to a second nest under a gate that led through a party-wall into a house yard.

Apparently, the ants from the curb colony had fallen upon the unctuous treasure which had dropped by their door, but had been disturbed in their "feast of fat things" by stragglers from the gate nest. These were attacked; others came, and were also attacked. Messengers ran to the gate nest for reinforcements; fresh squadrons issued from the curb colony, and so the battle grew. [McC. 11, p. 158.] It is probable that many like conflicts arise from rivalries for the possession of food; and, as in the above case, it is almost sure that a communal war springs out of a quarrel between a few, who, appealing to civic partisanship, finally enlist in their contention the two communities represented. Of course, conflicts between separate genera and species are readily explained by race antipathy.

Perhaps the most usual cause for the wars waged between our city Tetramoriums is the irritation produced by the encroachment of the mining workers upon their neighbors in the enlargement of their living-quarters. This is the more likely, as the most common period for the battles is the early spring, when the demand for larger room is greatest for the accommodation of the rapidly increasing young of the commune. The galleries, nurseries, and living-rooms for the numerous males and females are pushed out with such fervor that the excavated pellets rise into heaps and moundlets around the nest gates. In such conditions the overlapping of the new boundaries is inevitable, and in the tense nervous strain and high communal pressure under which the work is being pushed, the contact between

the rival parties is almost sure to be hostile. [McC. 3, p. 193.]

As the season advances, and the excitement of home-building and the keen fervor of communal parentalism abate, the war fever cools down, and peace prevails. Whatever be thought of the above as an explanation of the wars of our city Tetramoriums, it at least opens to us a secret chapter in the life of ant communities that awakens unusual interest. It is the story of underground wars. The surface combats are sufficiently intense and tragical. But there is a mystery about the battles waged within the dark caverns of the communes beneath the surface that clothes them with an air of romance.

Here are mining and countermining, just as one sees it in engineering campaigns of men, without the horrible accessories of explosives. Here a gallery is broken through; a sharp engagement follows; the assaulted party rallies to the defence of the works; the victors have pushed their way in; the vanquished fall back. But behind them a working detail has thrown up a strong barricade, behind which the besieged rally, and the battle goes on anew. In the case of such a "thief ant" as *Solenopsis fugax*, whose diminutive commune is constructed within that of some far larger host, the mining tactics and the spirited resistance may be observed in artificial glass nests, and they are extremely interesting to watch. A rather remarkable feature of the communal habits of this ant is that its swarming does not occur, as Forel observes, until September, long after that of its host ants (July, August). Thus they can get to the surface safely and swarm undisturbed, that belligerent period of their huge neighbors being overpast. [F. 5, p. 499.]

But in most cases no sufficient reason appeared for the frequent wars between the pavement ants. They are of one species, and in some cases, as it seemed to me, of one commune. Why should they fight? To be sure, civil wars are, unhappily, not unnatural to human societies, and indeed to social aggregations of humbler creatures. But somehow one expects better things of ants, even though their "ways" may not be held as "wise" in all things as those of Solomon's harvesters. Yet almost the first act of our city Tetramoriums, upon issuing from their winter quarters, is to engage in fierce war with their neighbors or fellow-formicarians. At times throughout the season these hostilities were renewed.

If, as we conjecture, the individuals be of one nest, is this nature's mode of distributing the species from the home centre, by causing the worsted party to emigrate? Or, supposing the combatants to be of separate adjoining communities, is this wasting pugnacity a sort of emmetonian malthusianism by which the surplus population is reduced and kept within due bounds, much to the comfort of survivors, and more to the satisfaction of man? Whatever theory or conjecture one adopts, he is apt to conclude that it is well-nigh as hard to find a really good reason for wars of ants as for many wars of man.

Another perplexing problem here arises: How do these ant warriors recognize friend from foe? The device of variant uniforms does not serve in this case, for they are all alike. Take a group of combatants in the hand and put them under a magnifier, as one can readily do, so intent are they upon mutual destruction. The most careful observer can note no difference be-

tween individuals of the two factions, yet they do infallibly and instantly distinguish their nest-fellows from the enemy. This is done by the antennæ, which are kept in constant motion, the tips describing sundry curves. At a meeting between ants these organs touch and embrace the face; if the parties be friends, they pass on; if foes, they straightway begin to fight. The newcomers, thronging to the battle-centre, where hundreds are struggling in a heap that is chaos to human eyes, but presents no difficulty to emmet senses, plunge into the seething mass and instantly recognize and join combat with their enemies. How is it done?

Thirty-two years ago, during the summer of 1877, while pondering this problem, it occurred to the writer that this recognition was based upon a certain odor, emitted in different degrees of intensity by the respective factions, or upon two distinct characteristic party odors. The degree of odor or difference in odors, he thought, might be dependent upon some peculiarity in the physical condition or environment of the antagonists. Supposing that there were any truth in this theory, it further occurred to him that the presence of an artificial and alien perfume strong enough to neutralize the distinctive animal odors, or degrees of odor, and environ the combatants with a foreign and common odor, would have a tendency to confuse the ants, and disturb or destroy their recognition of the distasteful and exciting element. In which case he conjectured that the result might be their pacification and reconciliation. Experiments were made to test this hypothesis. [McC. 17, p. 17.]

A number of warring Tetramoriums, taken upon a flower border, were placed together in a large glass vessel upon some soil. The jar was vigorously shaken

so that, if possible, the mechanical agitation might separate the combatants. The ants emerged quite unaffected by the miniature earthquake, to continue or recommence the fight. When the surface was well covered with them, and the battle was again at its height, a ball of paper saturated with cologne water was introduced into the jar. The ants showed no signs of pain, displeasure, or intoxication under the strong fumes. Some ran freely over the paper. But in a few seconds the warriors had unclasped mandibles, released their hold of enemies' legs, antennæ, and bodies, and, after a brief interval of seeming confusion, began to burrow galleries in the earth with the utmost harmony. There was no renewal of the battle. The quondam foes dwelt together for several days in absolute unity and fraternity, amicably feeding, burrowing, and building.

This experiment was followed by others, varying the conditions and the individuals, but holding to the species. The result was always the same with *Tetramorium cæspitum*. The perfume of the cologne proved a complete pacificator of the contending parties, and so far verified the theory. The alien odor neutralized the distnctive nest odors which had served to identify friends and foes, permitting them thus to return to their normal neighborliness; or in some way had mollified the hostile parties, and transformed them from enemies into amicable associates.

Similar experiments were tried with colonies of carpenter ants taken from the Alleghany Mountains and from Logan Square, Philadelphia. These pointed to a conclusion just the reverse of the above. Whatever the cause—a failure of the experimenter in arranging his conditions, or the presence of some disturbing element

that was overlooked, or because one or both parties were too far saturated and seasoned in their own native nest-odor to respond to the cologne treatment—the fact was that the experiments led to opposite conclusions.

However, I had little doubt then, and have none now, that the original inference was substantially true in the case of wars between separate communes. The ants were recognized by a special odor which they absorbed during residence, and which was stronger or weaker according to age and environment and conditions unknown. How acute and delicate and accurate must be the sense organs seated in the antennæ, which are instruments of recognition, the facts related will show.

"He does not carry the odor of my species, my commune, or my caste. Therefore, we will fight!" To a human philosopher meditating upon these things, it seems a small difference on which to divide two such closely related creatures into hostile camps. But mayhap he who counts this for abatement of the common fame of ants for wisdom might find, in the history of human wars, originating causes as insignificant and unreasonable.

CHAPTER XII

ALIEN ASSOCIATES AND AFFINITIES IN ANT COMMUNES

THAT "no man liveth to himself" is an aphorism not to be questioned in human communes. That no community lives to itself is equally true. And this applies to ants. Their societies are established in the vicinage or in the midst of numberless creatures, most of them, like themselves, free citizens of that wild life which nature has organized and maintains in the cultivated parks and fields of men no less than in a wilderness. He deludes himself who thinks that he ever is delivered from the environment of wild things. Of the large and grosser sorts, it may be; but civilization never will tame or exterminate the innumerable hosts of minor creatures, seemingly as wild now as in the primitive Eden, that inhabit our day-world and, even more, our night-life.

The ants are examples of this. They find and keep a foothold everywhere. I have surprised immense communities in the heart of great cities. I have shown an American farmer, who boasted in the tilth of his acres—under the plough since the first English settlements—that he could scarcely put down a foot in a walk through a field without placing it upon a little commune of meadow ants.

These cases do not stand alone. A naturalist would

soon point out to our farmer that many other living things have possession of his domain whose ancestors were probably here before Columbus, and whose descendants will doubtless outlive the Republic. These are the creatures with which ants have to neighbor.

Close neighbors they are at times; sometimes hostile, sometimes indifferent, sometimes friendly. In the course of ages of neighboring experience, strange inter-relationships have been established, presenting some of the most interesting and puzzling features of emnet communal life. To a few of these our attention will now be turned.

Taking up once more our mountain mound-builders, we note certain loose relationships established between them and some other insects in cold weather. Winter deadens energy and subdues combativeness, and, when severe, suspends activities. One will then come across colonies of our common white ant (*Termes flavipes*) imbedded within the great cones of *Formica exsectoïdes* Bunches of cockroaches are found, and sundry beetles, with other insects, that in the adult or larval stage naturally domicile in the ground.

Most of this sort of neighboring is the result of that truce which Jack Frost enforces, and will largely disappear when spring relaxes nature and insects come to their normal antagonisms. But it shows how certain companionships may have been formed which, at first accidental and temporary, were found to be harmless, more or less helpful, and in some cases highly beneficial. Use and heredity, operating upon casual affinities and the acquisition of a common nest-odor, may have thus brought about those examples of symbiosis, or sympathetic companionship, which exist among ants, and between them and other creatures.

Let us consider a little more in detail this theory that winter conditions may have influenced the formation of communal affinities and associations between ants and alien insects, as well as between separate species and genera of ants. Do the facts seem to justify it? One night, while encamped among the ant-hills of Brush Mountain, Pennsylvania, late in August, 1876, there fell a heavy frost that well disclosed the effect upon ants of such temperature changes. [McC. 2, p. 284.] At 3.45 A.M. I made the round of the hills, and found their inmates in a state of semi-torpidity. Tapping the surface and stamping upon the surrounding stones, which heretofore had always brought out a host of workers, failed to arouse a single sentinel. I dug into one mound eight inches before finding ants, and these showed little activity—a marked contrast with their usual mode.

Then the aphis feeding-grounds were inspected. A white-oak tree near a stone wall, whereon numbers of aphids were domiciled, was a popular emmet resort. Mounting the wall, I turned the lantern light upon the overhanging boughs. The aphids were in their places on the leaves and branches, surrounded and covered by groups of ants. But all were semi-torpid. The frost had surprised them at their feast, and left them frigid upon the spot. Many of them had abdomens distended by crops gorged with honey-dew, which showed translucent as the light fell upon them. In my long experience of a full generation in observing emmet ways, I recall few more striking visions than that. If one could only have preserved those congealed specimens for the museum!

But as the sun returned with his wonted August fervor, the statuesque groups began gradually to dissolve.

First, with sluggish movements, slowly stirring; then more vigorously, as the sunshine fell upon the branches; until by nine o'clock the tree-paths were thronged with workers, most of them repletes, and homeward bound. So also it was on the mounds. As the sunlight pierced the woods, and fell upon them and warmed them up, they resumed their normal activity. The benumbing effect of the frost upon the insects had been no doubt intensified by its suddenness, and the high temperature that had preceded it.

The above facts led me to studies of the winter condition of the mound-makers, which were made late in October, 1876, and the latter part of February, 1877. [McC. 2, p. 286.] It was found that the winter tended to drive alien insects to the formicaries for harborage. Lodged in one nest was found a colony of our native termites. They were in an unfrozen part, exposed to the sun, occupied a space of about four inches square, and were then (February 14th) quite lively. Near them was a large herd of roaches, a hundred or more. The ants in the mound were not torpid, although their characteristic vigor and activity were suspended. It would not have been possible for the termites to hold such a position in midsummer; they would have been eaten. Such a cluster of cockroaches would have been equally impossible; it would have been scattered and destroyed. This is doubtless the general experience. Wheeler [W. 1, p. 30] found that in Texas, during autumn and winter, the nests of *Formica gnava* teem with alien insect guests of various orders, larvæ and adult, that are rarely seen in summer.

How shall we account for this? In the case of the mound-making ants, there seem to be two factors, one

negative and one positive, in drawing termites and roaches to the nests. The first is the benumbing effect of cold, which suspends the emmet energies, and therewith suspends hostile acts toward intruders upon their domain. The second is the greater warmth and comfort of the mounds. These are built of a light composite of soil-pellets and pine and other leaves, which form more congenial quarters than the surrounding earth. The galleries that honeycomb them are air-chambers which mitigate the cold and conduce to natural warmth.

Besides, to errant insects abroad in the autumn in search of winter quarters, the upraised cones of the ants are prominent and inviting objects, the most available for them in the vicinage. So there the rovers settle and stay until, in the revived activity of returning spring, the ants make the premises entirely too warm for them.

These facts have at least a conjectural bearing upon the origin of some ant affinities and associations. The importance of the local nest-odor, and its intimate relationships with the friendly or hostile attitude of ants toward their fellows, has already been pointed out in chapter xi. May it not follow that the temporary and accidental lodgment of these alien insects upon the ants' nests may have led, in occasional cases, to the acquisition of so much of the local nest-odor as partly to conciliate the ants? This complaisance may have been increased by the inactive condition of the ants in early spring, and at least made them tolerant of the presence of their guests. This condition, acting upon temperaments specially adapted to such an estate, together with the discovery of some mutual advantage in nourishment or massagerie, through the shampoo *déjeuné* or other-

wise, may have developed at last into the habits of the permanent myrmecophile. This may be suggested, at least, as a contributory factor in the natural evolution of a remarkable feature of ant communes.

A brief observation will illustrate the advantage which some of the alien ant-guests find in the connection, and which must strongly tend to hold them to it when once formed. Certain little crickets of the genus Myrmecophila live with species of Formica and Camponotus, and a diminutive, nearly blind cockroach (*Attaphila fungicola* Wheeler) inhabits the nest of the Texas cutting ant. The behavior of these myrmecophiles shows that the surface of the ant's body must be covered with an unctuous, highly nutritious, and, it may be, antiseptic secretion, probably derived from the salivary glands of the host-ant or other members of the colony. This secretion is also spread over the eggs, larvæ, and pupæ, and it seems to retard the development of pernicious moulds, since these tend to grow only on the larvæ and pupæ that have been isolated for several days from the workers and queens.

Both crickets and cockroaches live by licking the surfaces of their hosts. The former remain on the ground and reach up to lick the legs and bodies. The latter climb upon the backs of the large Atta soldiers and feed from that position. [W. 4, p. 14.] The advantage to the ants may be simply the pleasure of the massage and the satisfaction of being clean, although there may be other advantages now unknown. However, we shall presently see that such affinities and associations may exist even under strong disadvantages apparent to human observers, at least.

Among the ant-loving (myrmecophylous) beetles

found with our Alleghany mound-builders is a Claviger species (*Tmesiphorus costatis*) collected during the winter. Doctor LeConte showed me (1876), in his rich collection of Coleoptera, several of these taken at Bedford and Columbia, Pennsylvania, among which were *Cedius ziegleri* LeConte, and others which he spoke of as "undescribed specimens of Homolata and an unnamed species of Oxyopoda." These were small brownish insects with slight pubescence.

(By courtesy of American Museum of Natural History)

Fig. 85—THE BEETLE XENODUSA CAVA LECONTE

From a colony of *Formica Schaufussi-inserta*. (After Wheeler)

The most interesting of these ant-affinities (myrmecophiles) was his own species, *Xenodusa* (Atameles) *cava* (Fig. 85). This is a reddish-brown beetle, about one-fifth of an inch long, with tufts of yellowish hair-like tubes on the sides of the abdomen. From these hairs exudes a sweet secretion upon which the ants feed, as upon the honey-dew of aphides, and it is this fact which attracts ants to them or assures their toleration of them. Specimens of this beetle were also taken by or for LeConte in ant-nests of unknown species in Maryland, Illinois, and Michigan. Among these was one still held in its host's mandibles, as if taken while in flight from the disturbers of its nest, and clung to with unrelaxed jaws in the alcohol which killed it. Our American carpenter ants

(Camponotus) in several species and varieties are often the hosts of *X. cava.*

All the beetles of this group, the Lomechusa group of Staphylinids, are true ant-guests. They are treated by their hosts, both as adults and larvæ, quite as their own fellows, being fed, cleansed, and carried about. Indeed, it is said that in case of real or fancied danger, the beetle larvæ and pupæ have precedence of their own young in the ants' attention.

This is all the more remarkable because, according to Father Wasmann (S. J.), a devoted and distinguished observer, and perhaps our highest authority on myrmecophilous insects, these adopted citizens repay the host's care by ravenous assaults upon their own brood, devouring numbers of eggs and larvæ. The effects of this, in weakening the commune, are apt to be serious. It works toward deterioration, as Wasmann shows, in another way. This brood-parisitism appears to originate a curious form of abortive individuals intermediate between the female and the worker, known as pseudogynes. They are cowardly and indolent. They decline to dig and nurse, and trot about the nest aimlessly. Thus, in sharp contrast with the valiant and active workers, they hold a sort of "frustrate existence."

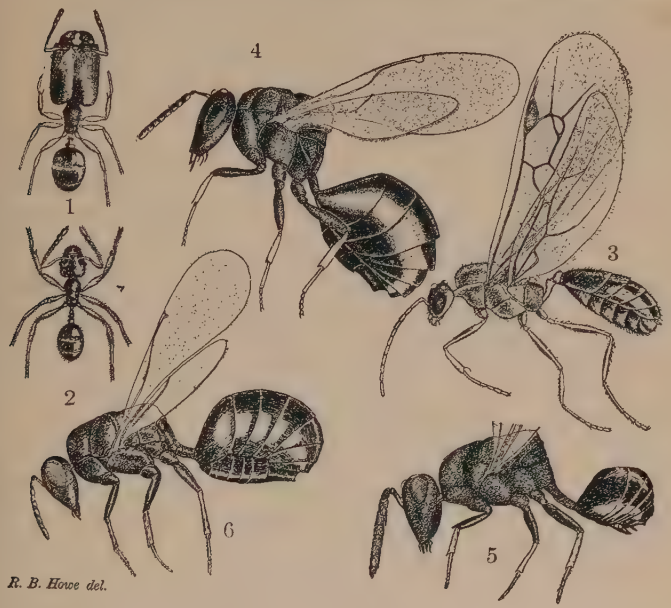
How comes this about? Wasmann believes, and seems to prove, that it is caused by the diminished care and diet due to the queen larvæ for their full development—a case of restricted growth through defective nourishment. A brood of beetles (Lomechusa) begin life with a brood of worker-ants. The beetle larvæ, as they appear, are not only generously fed by the ants, but begin to feed upon their eggs and larvæ; and as they are extremely voracious and grow rapidly, they devour

enormous numbers. This makes a great breach in the generation of coming ant-workers. These are essential to the commune, and the adults aim to make up the lack by converting into workers some of their larvæ destined for queens. This results in that intermediate form, neither worker nor queen, but a spurious female—a pseudogyne.

At the same time the infatuated ants, under the impression that their guest-larvæ are valuable to the commune, lavish on them care due to their own progeny. Thus, again, arises a neglect of the young ant queens which stays their growth, and diverts their development toward the pseudogyne. It is the old story of the cuckoo among the birds, who thrusts her egg into another bird's nest, and secures for her parasitic offspring the nurture due the legitimate fledglings.

All this goes sadly against the general reputation of ants for wisdom. But perhaps it might modify our censure to mark our own history or survey existing society. Would it not be found that we have not only tolerated but have fondled and nurtured human parasites in official, family, and private life, greatly to the loss of the commune? Our parasites destroy the virility and the very life of our young, and we endure them. They waste our resources by graft and neglect of duty and pernicious schemes and perverted policies, and we give them our suffrages and support. We open our homes and our harbors to guests who repay our hospitality by implanting among us doctrines, practices, and persons that carry the seeds of communal disorder and decay. Misguided by such social and political unwisdom, it fares with us, and will ever fare, as with ant communes inoculated with Lomechusan beetles.

It might therefore be maintained, with a good degree of verity, that social men in their communal life show no great superiority to social insects in dealing with the



(By courtesy of the American Museum of Natural History)

Fig. 86—PHEIDOLE INSTABILIS AND ITS PARASITES

1. Big-headed soldier of *Pheidole Kingi* André var. *instabilis* Emery. 2. Typical worker of *Pheidole Kingi instabilis*. 3. Male of the same. 4. *Orasema viridis* Ashmead, female. 5. Male. 6. *Orasema coloradensis* Ashmead.

parasites that infest them (Fig. 86). Especially when we consider the vast advantage of men over ants in natural endowments, the relative unwisdom of the latter does not bulk so largely.

A Chalcid fly, *Orasema viridis*, is parasitic upon colonies of the ant *Pheidole instabilis* (Fig. 87). The chalcid is a beautiful insect, decorated with metallic green, and blue,

violet, yellow, and black, with iridescent wings. This polychromatic creature, when seen among its ruddy hosts, amid the shining red and black seeds stored for food (the ant being a harvester), gives a brilliant appearance to the nest. But it is a beauty which bears the germs of death to those who cherish the possessors.

The mother Orasema posits her numerous eggs upon the under surface of bodies of the young ant pupæ,

(By courtesy of the American Museum of Natural History)

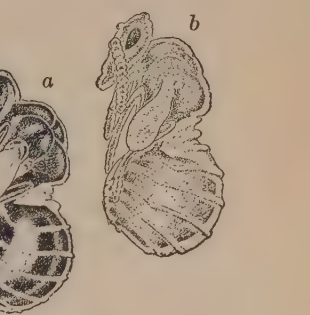
Fig. 87—ORASEMA VIRIDIS
A parasite in various stages of development on the surface of the ant *Pheidole instabilis*

near the head. She chooses for this the pupæ of the large forms—soldiers, females and males—not the small workers, as having the richest store of nutriment. Here the parasites cling and grow rapidly, feeding upon the juices of their host. When the parasites reach the pupal stage—within two or three days—they are released by the worker-ants from their host, now a lifeless mass. Thenceforward they are objects of special care by the Pheidole workers, who tend them as their own offspring, not only in the pupal, but in the imago stage. Indeed, so great is this infatuation or delusion that, as in the case of the Lomechusan beetles, when a nest is disturbed

the Orasemas are looked after before the ants' own brood! [W. 6, p. 5.]

The life cycle of Orasema from egg to imago is a week or ten days. Thereafter the adults are licked and fondled and borne about by the ants, and fed by regurgitation. The guests commonly take these attentions passively; but sometimes—just as growing boys resist embraces—seek to avoid them. One cause of difference between hosts and parasites emanates from the preference of parasites for free air, which, as soon as they mature, both sexes aim to reach. Their hosts, having different views as to the relative values of light and darkness, guard the exit gates, and, seizing their guests, drag them back to the dark inner rooms.

This tendency of the Orasemas results from their natural habit of mating in the open air, after which the fertilized females seek a Pheidole nest wherein to start a new brood upon the round of parasitic life above described. After pupation the mature Orasemas spend much of their time lying on their sides among the ant larvæ and pupæ. They contribute in no manifest way to the welfare of their hosts, their only interest in them being the selfish one of securing nurture for themselves and a brooding host for their offspring (Fig. 88). One finds nothing in the life history of insects more puzzling than such seeming anomalies as the above associations between ants and parasitic chalcidids and beetles. We



(By courtesy of Am. Museum of Nat. Hist.)

Fig. 88—PUPA OF ORASEMA

a—Just before pigmentation. *b*—Pigmented pupa ready to hatch

are used to some such social phenomena among men, who seem to have a perverse strain that forces their development along aberrant lines toward disadvantageous and destructive ends. But in these simpler children of nature such conditions surprise us as quite abnormal.

Once in a while, however, the ants do seem to shake off the spell that binds them and awake to the true nature of their guests. In one of Professor Wheeler's artificial nests of *Pheidole instabilis* the workers rose upon the adult Orasemas, after they had remained in the nest several days, and killed and dismembered them. But a doubt remains as to whether this was due to their discovery that the victims were predatory aliens, or to some special stress of hunger or other cause; for the ants also killed and dismembered their own females, and after that reared only their fellow-workers and intermediates, as though they purposed to spare none but the caste that furnishes the lightest consumers and the helpers, and to free themselves from mere dependents. Like action on the part of worker-ants of other species has been known in times of special stringency in the food supply.

Another of the parasitic aliens that associate themselves with ants is a little Dipteron fly, *Metopina pachycondylæ* Brues. While sorting out a number of larvæ of a large black Ponerine ant, *Pachycondyla harpax*, several were found to have larvæ of the above insect attached to the region of the first abdominal segment. It quite encircled the ant larvæ, like a collar about the neck, "a kind of Elizabethan ruff." The posterior end of the parasite was provided with a sort of suction disk, by which that part could clasp its host so tightly that the fore part of the body could be released and swung out

of position without the creature losing its hold. [W. 6, p. 45.]

The experimenter transferred a colony of the ants to an artificial nest for observation, and fed them with a number of young larvæ of the ant *Camponotus maccooki*. These the Pachycondylæ proceeded to tear to pieces, freely lapping the exuding juices. Then they placed the pulpy remainders in the ventral surface of their own larvæ (as on a serving-dish), which lay upon their backs in a chamber dug in the earth of their nest. This chamber was so situated under the glass cover that the actions of both ants and larvæ could be observed distinctly. The ant larvæ thrust out their brown heads and began to feed. The Dipteron larvæ, by some unknown sense made conscious of the presence of food, unloosed their heads and necks without releasing their caudal attachment, and dipped their beaks into the mess. Thus the two young creatures so widely apart in structure and destiny were here united in their cradle-life and became fellow-trenchermen.

The experiment was repeated a number of times, and with various sorts of food. The result was always the same. To quote the picturesque language of the observer, he was always "able to witness the strange banquet—the dwarf reaching from the shoulder of the ogre, and helping himself from the charger formed by the trough-like belly of his host." Pieces of ant larvæ, beetle larvæ, myriapods, etc., when served up to the Pachycondyla larvæ, were partaken of with equal zest by larval host and guest. The latter were thus shown to be true commensals — "perhaps the most perfect commensals, in the original sense of the word, to be found in the whole animal kingdom."

As a bit of by-play, we learn that when the ant larvæ lay close together a Metopina would reach over and help itself from the portion of a neighbor, keeping the while its rear attachment. Sometimes, when the rations were exhausted, the Dipteron would nip the tender hide of a near-by ant larva till it squirmed with pain, or it would tweak its own host. The suggested purpose of this action was to attract the attention of the nursing workers to the wriggling ant larva, and thus prompt them to replenish the larder.

Both kinds of larvæ were cleansed by the nurse-ants, who, if they were conscious of the presence of the parasites, made no discrimination between them and their hosts. Indeed, as this species of ant is almost blind, it seemed doubtful if they really could distinguish larval host from larval guest, the latter possibly being taken for a mere enlargement of the former's neck.

One hesitates, however, to accept a theory which implies such a lack of sensitiveness in the perceptive organs of insects commonly so highly developed. However, as ants are notoriously devoted to the genuine antennal "tone" of society, and as the Metopinæ, from the egg onward, are imbued with the true Pachycondyla atmosphere, the distinction between the two larvæ might readily be lost in the common odor. Yet this would equally account for their sparing the guest, even though its nature were perceived.

The next stage of development in the life history of these strange yoke-fellows is equally interesting. When the ant larva is mature, and nature stirs within it the great unrest that precedes transformation, it sets its spinning glands in motion, and begins to weave around itself the brown cocoon, or closed silken sac, within

which the change occurs. It moves back and forth, around and around, issuing from the mouth-parts the liquid silk that hardens about its snug house of change until that is complete, when it falls into the quiet of pupation.

What becomes of its Dipteron yoke-fellow during these movements? Surely they could not be wrought with that encumbrance upon it? No; it has disappeared. Whither? The mystery was solved by opening an ant cocoon. Therein lay the Metopina safely and snugly tucked away in its own little puparium lodged in the posterior pole of the cocoon. It had dropped off its host's neck, had taken station close by the opposite end, and had been wrapped within the silken sarcophagus. Thereto it had attached itself, had wrought out of its own larval skin an envelope (it is not a spinner like the ant), and in that it pupated. The quarters were large enough for both occupants.

Now follows another interesting chapter in our story of these humble lives. Duly the time comes when Nature bids the transformed antling break forth from its silken coffin. It makes with its mandibles a rent at the anterior pole, favored, it may be, as with other species, with the obstetrical aid of worker nurses. It creeps out, and, though still a callow, is soon numbered among the active members of the commune. The empty cocoon case is carried by the workers to the common dumping-ground for waste products of the commune.

But what, meanwhile, has befallen Metopina? In the struggles of the antling to get out, and from the cutting and tearing of the nurses to deliver it, has the young Dipteron escaped injury? Fortunately it so "happens" —if that be the lawful word—that its puparium is *in-*

variably formed at the posterior pole of the ant cocoon, directly opposite the anterior pole from which, as the point next to its jaws in its recumbent position, the antling emerges, and to which, as the point of fracture, the strain and force within and without are directed. Thus the little squatter sovereign, in its tiny puparium, goes scot-free and quite unharmed to the communal kitchen-middens, along with the abandoned cocoon of its yoke-fellow. So it befalls that, as Professor Wheeler quaintly puts it, "after a privileged existence as free pensioner and bedfellow to a generous host, it is unwittingly carried away in the worn-out bedclothes and consigned to the family rag-pile."

Here one must note another admirable "happening." The period for the Dipteron to emerge falls later than that of the ant. Therefore its hatching-place is the emmet dump where it has been deported by its foster-mothers, the ants. Fortunately for the newly fledged insect, since nature has not furnished it with fit implements to break through such formidable walls, it finds a wide and effectual door already open in the tough cocoon. It is once more debtor to its sometime host for that hospitality which not only "welcomes the coming," but also "speeds the parting guest," and crawls out of the rent made by the emerging antling.

Thenceforth its new world lies before it. It finds its mate. It follows the mysterious impulse of its kind, and returns to the commune whence it came, or flies to some other colony of *Pachycondyla harpax*, and, mousing among the robust larvæ thereof, drops its minute egg, and— But there our story of the cycle of her life must end.

And what a wonderful story it is! Here, if ever, one

may apply Marlowe's phrase: "Infinite riddles in a little room." It has taken the patience, skill, and experience of the trained naturalist to trace it and unfold it to us. But it needs no expert to note the admirable adaptations by which a minute fly has been borne on, step by step, in utter helplessness, through the successive stages of a dependent being, from a mere speck of vital matter to a winged insect, armed with the instinct to invade an ununknown world and propagate its kind. How great and how infinitely exact must be that Over-Force that dominates nature, which can include within the compass of laws that regulate the universe a series of adaptations like these which guard the life of a two-millimetre parasitic fly! It amazes, while it perplexes one, to account for it all. Yet, in the face of great Nature's workings, one may venture to recall the proverb of Spenser (not Herbert, but he of the *Faerie Queene*):

"Ill can he rule the great who cannot reach the small."

In contrast with our studies of the chalcid *Orasema viridis* and the beetle *Xenodusa cava*, it is pleasing to record that the association between Metopina the fly and Pachycondyla the ant is apparently wholly benign—at least, under ordinary conditions. The guest does not prey upon its host; no physical injury seems to follow its enforced companionship; and the bare particle of food filched from the ant larva does not tax the supply-department of the commune or cause its workers to stint their own dependents. The larval hosts themselves are as large and healthy as others in the nest, and produce normal pupæ. It is a case of "all's well that ends well."

These are but types of numerous examples of those

strange and seemingly "unnatural" companionships with alien creatures which have grown up in ant communes. The literature thereof is already large, and is continually growing as entomologists push their investigations more widely and carefully. It would be impossible to present here an abstract of even a tithe of the known facts, but from the typical ones which have been chosen the reader may fairly judge of the general tenor of the rest.

CHAPTER XIII

APHIS HERDS AND ANT ASSOCIATES

APHIDES are the alien insects with which ants have the most intimate relations. The manner in which ants search out, attend, protect, and domesticate these creatures need not here be repeated;[1] but as these consociated relations are so widely and popularly known, it seems well to distinguish them from other ant guests and associates by a more detailed description than could be given to other myrmecophiles.

The aphides, or plant-lice, belong to the order Hemiptera and the sub-order Homoptera, including such insects as cicadas, or harvest flies, and the bark-lice. They range from small to exceedingly minute, but make up in numbers what they lack in size, and include some of the most destructive pests known to the agriculturalist and horticulturist. They are soft-bodied and gregarious, and most numerous in the wingless forms. The eyes are usually quite large and of a dark color, and the antennæ of many species long and threadlike. The beak is two or three jointed, and in some cases as long as or longer than the body. In the leaf-feeding species the legs are rather long and slender. In the root-feeding and gall-inhabiting forms the legs are short and stout.

[1] See *Nature's Craftsmen*, chap. iii.

The wings are thin and transparent, with dark veins on the anterior margin.

The order Hemiptera is composed of beaked insects, and the wings, where these organs are present, are of the same texture throughout, and close, rooflike, over the body. In several groups they are transparent, and have many strong veins. In others they are tough and opaque, and show many different colors. The head is broad but usually short, without any neck, and has the beak rising so far under the breast that it seems to be attached thereto, and may be closely folded against it.

The honey-dew which aphids yield, and which gives the occasion for their peculiar connection with ants, is obtained by the insertion of the beak into the tender bark of the plant. The pumping apparatus is then set in play and the sap withdrawn into the body of the insect. It is a minute type of the mode of getting sugar-water by "tapping" the trees in a sugar-maple camp in Vermont or Ohio. The sap thus withdrawn probably undergoes some slight chemical change within the insect. It differs in taste from the sap of the plant, having an acrid flavor, in some degree resembling the taste of honey, thus justifying the ordinary phrase "honey-dew." It does not, at least as far as the author's observations have gone, proceed from the nectaries, or nectar tubes, as has been commonly supposed, but is a fluid excrement. This, however, differs from the ordinary excrement, which is a whitish, semi-solid substance, voided in long cylindrical strings or minute whitish balls, which roll up like quicksilver globules.

The injury produced upon the plants by this tapping results from this attempt of the insect to procure its natural food. The numerous punctures made within

a leaf cause it to shrink up, forming little rolls, or tents, within which immense numbers of the insects dwell. With them ants will commonly be found, attending them simply for their honey-dew; but often they get the blame of the damage done by their companions, an experience that is apt to befall higher creatures. Minute as each individual is, when multiplied by hundreds and thousands the injury wrought upon the numerous leaves of the plant is sufficient to affect their health.

When the punctures are made upon the roots they result in little gall-like swellings, which harden, destroy the natural function of the rootlets, and finally result in death. When a large number of roots is thus affected, the plant, of course, has lost its power of deriving sufficient and wholesome nurture from the earth, and so falls into decay. Other species of aphides secrete from a part or the whole of the body a whitish powder or bloom, or numerous filaments of fine cottony matter in which they become completely enveloped.

In the various stages of development the nymphs of some species secrete globules of honey-dew several times larger than themselves. Sometimes the globule completely envelops the nymph. After they are moulted, the nymphs usually find a new feeding-place, leaving the old skin attached to the drops of honey-dew. The moulted skins, the last moulted especially, often retain their form so perfectly as to seem like a live nymph.

Professor Slingerland, in his account of the "pear-tree psylla,"[1] says that it ejects immense quantities of honey-dew, which cover twigs, branches, and trunks of the trees, and even the vegetation beneath. This

[1] M. V. Slingerland, Bulletin No. 44, Cornell University Agricultural Experiment Station, 1902: "The Pear-Tree Psylla."

appears soon after the leaves expand, and is found throughout the season. I have seen American forest trees attacked by aphids, from which the honeydew was flung out in such quantities that it sounded like the patter of rain-drops as it fell upon the dry leaves and grass beneath the infested branches. The whole surface of the ground underneath was covered with the liquid sweet, and thousands of ants, bees, wasps, and various other insects had assembled to the forest feast.

The reproductive processes of aphids are extremely complicated and remarkable, and have been the subject of much careful study and experiment. At certain seasons of the year, usually late in the summer or early autumn, individuals of both sexes are produced, and the females lay eggs which in some species hatch immediately. In others they remain over the winter. Sexed aphids were formerly supposed to be the winged form, but late discoveries show that there is not necessarily any connection between the wings and the true sexual organs, the wings being simply an adaptation for migration from one plant to another.

The form hatching from the egg is known as "the stem-mother," and in the course of a few days begins the peculiar process of reproduction known as parthenogenesis, or agamic reproduction, bringing forth her young alive and in rapid succession. This process has been likened to the multiplication of certain kinds of plants by slipping and budding. The offspring of the stem-mother begin to produce viviparously in the course of a few days, and in this way the multiplication of individuals proceeds at a most extraordinary rate, extending to several generations.

In the pear-tree psylla, for example, the hibernating

winter brood begin to pair and lay eggs in the first warm days of April. The eggs are placed in the creases of the bark, or in old leaves, or scars about the bases of the terminal buds of the preceding year's growth—some also upon the side. They are usually laid singly, but rows of eight or ten are sometimes found. The eggs are scarcely visible to the unaided eye. It would take eighty of them placed lengthwise to measure an inch. A short stalk on the larger end attaches the egg to the bark, and a long, thread-like process projects from the smaller end.

About the middle of May most of the eggs are hatched and the hibernating adults have disappeared. Immediately after emerging from the egg the minute nymph seeks a suitable feeding-place, and is soon at work sucking the sap with its short beak, which appears to arise from between its legs. The favorite feeding-places of the nymph are in the axles of the leaf and the petioles and stems of the fruit. Sometimes in early spring they crawl into the buds. When the axles of the fruit-stems and leaves are full, the nymphs gather in closely packed clusters about the base of the petioles and stems. If very numerous, they gather on the under side of the leaves along the mid-rib. They move about but little, and sometimes become covered with their own honey-dew. If disturbed they crawl around rapidly.

The only time the nymphs seem to stop feeding is during the casting of their own skins, which become too small and give place to new and elastic skins formed just beneath the old ones, in the ordinary method of moulting insects. At the last moult, which occurs about one month after the nymph emerges from the egg, the adult insect appears.

The adult has habits quite different from those of the nymphs. It has strong legs and wings, which permit it to spring up and fly away quickly upon the slightest jar of the plant or the near approach of the hand to its resting-place. The hibernating forms gather, but quite sluggishly, and are readily captured when found. The summer forms fly from tree to tree, and can easily be borne by the winds long distances, thus infesting neighboring orchards and plants. The adults are also provided with a beak, with which they feed upon the tissues of the leaves and the tender twigs of the trees. They seem to have no favorite feeding-place.

Three or four days after transformation from the nymph stage the adults of the spring and summer broods pair, and egg-laying begins for another brood. These eggs are usually laid singly, sometimes several in a row or group, on the under side of the tenderest leaves, among the hairs near the mid-rid or on the petioles near the leaf. Sometimes the mother places an egg or two in each notch of the toothed edge of the leaf. These eggs of the summer brood resemble those of the hibernating adults, but hatch in from eight to ten days under more favorable conditions.

Fortunately for the safety of vegetation, aphids have a number of natural enemies. Among the most effective of these are the well-known "ladybirds," which are beetles, belonging principally to the Coccinella. They are small, roundish insects, generally yellow or red, with black spots, or black with red or yellow spots. There are many species, and they are generally distributed among the plants, and are familiar objects to those who cultivate flowers. They live both in the perfect and the immature state upon aphids, their natural food,

and their services are extremely valuable. Perhaps it is this which has created the friendly popular sentiment toward these pretty beetles. It is rare to hear an utterance of dislike toward them, and they fairly rival butterflies as general favorites. Their young are small, flattened grubs of a bluish or blue-black color, spotted usually with red or yellow, and furnished with six legs near the forepart of the body. They are hatched from little yellow eggs laid in clusters among the plant-lice, so that they find themselves at once within reach of their prey, which from their superior strength they are able to seize and slaughter in great numbers.

Another enemy of the aphis is the golden-eyed lace-winged fly (*Chrysopa perala*), which is of a yellow-green color, and has four wings resembling delicate lace. It gives out an offensive odor. It suspends its eggs by threads in clusters beneath the leaves or where plant-lice abound. The larva is a long and cylindrical grub provided with jaws moving laterally, which perforate the body with a hole, through which it sucks the juice of its victims. It requires only one minute to kill the largest aphis and suck out the fluid contents of the body.

This sketch of the life history of aphids will be appreciated by those who have learned the story of their relations to the ant. That their value as food producers should have been discovered and utilized by such inveterate scouts and scavengers and cosmopolitan feeders as ants is not strange. But that they should have acquired the art of "milking" them; should have learned to seclude them for their own use within walled enclosures, as sheep within a fold; even to rear them within their own bounds and dwelling, tending them as a herder or farmer does his domestic cattle, protecting

them and fleeing with them in predatory raids—all this forms a chapter of natural history so strangely analogous to the ways of agricultural society as to link the ancient and wide-spread human interest in ants with the life of the aphids, which lend themselves so readily to their remarkable uses. This natural adaptation is, of course, a factor in the development of the habit which here has commanded our attention.

That which makes ants *particeps criminis* in the destruction wrought by aphids is the remarkable habit which they have acquired of deliberately housing the aphid eggs and raising therefrom the adult forms. From their breeding-camps and nurseries they transport these domesticated herds to the plants which they elect to attack, whether on root or stem. There the aphids at once thrust in their beaks and begin to draw out the sap, which the canny "proprietors" appropriate as honey-dew. It is thus indirectly, and not by any direct injury inflicted upon plants, that ants become at times injurious insects. Otherwise they take rank with the benign insects, by aiding the fertilizing of blossoms by their frequent visits for nectar, and the formation and shifting of tillable soil by digging out their subterranean homes.

Our attention must now pass from the communal associations which have been established between ants and alien insects to those existing between ants of separate species. These are numerous and greatly varied, and only a few typical cases can be considered here. Among the consociated communes of ants there are few whose relations are more interesting than those existing between *Myrmica brevinodis* and *Leptothorax emersoni*. The latter is a small species (much smaller than Myrmica)

and in forming its compound nest it shows a strong purpose to keep its own living-quarters quite distinct from its associates, although the workers mingle freely with the Myrmicas in their larger galleries. As compared with these, the gangways of Leptothorax are small, and evidently are so made and kept to maintain their isolation and hold their robust neighbors at a distance. It is only by a deliberate onset of sappers and miners that the larger ants can make way through their dwarfish associates' narrow lanes; and this is occasionally done, although for the most part the Myrmicas seem content to let the Leptothorax alone.

A sectional view of the joint underground commune of the two species shows the parts occupied by Leptothorax quite apart from Myrmica, but united thereto by their narrow alleys. The "Chinatown," or foreign quarters of some of our cities, might be suggested, not inaptly, as a somewhat analogous communal subdivision on racial lines.

In spite of this maintenance of independent quarters for themselves and their offspring, the two species are truly symbiotic. They intermingle on the most amicable terms; they run about together in the main galleries and large myrmican chambers; and they exhibit, under favorable circumstances, the chief bond of union that holds this strange compound commune together; it is the old, old "bread-and-butter" bond that draws together communities of men. The Leptothorax under normal conditions obtain their food from the Myrmicas, and from them alone. [W. 4, p. 14.]

A peep through the glass roof of an artificial nest shows a Myrmica worker standing stock-still in a gallery with a Leptothorax mounted upon its back. What does

it mean? The little creature is licking its great host, who bows gently beneath the osculation as the manipulator passes from back to neck, from neck to head, from head to face. The recipient plainly enjoys the operation, and reminds one of the domestic cat purring under the stroking of a mistress.

Here and there other worker Myrmicas are undergoing the same treatment, and the queens and the males, too. In this corner a Myrmica queen, a giantess beside her dwarfish guests, has four or five attendants, all mounted in different positions upon their huge host, and working away eagerly. Indeed, the process seems to be an exciting one to them, as their abdomens are kept in almost constant stridulatory movement. Doubtless it is agreeable to both parties; but the act of Leptothorax is not one of pure benevolence. This is the famous shampoo *déjeuné*—the dinner shampoo of ants—that we are seeing through our trained observer's eyes. There can be no doubt that the wee operators obtain some substance from the body surface of their hosts, but what is its nature is not easily ascertained.

It has been suggested that it is a secretion from cutaneous glands, faint but agreeable and edible, and distributed over the body surface, or that it is a salivary secretion spread over the Myrmicas by that mutual licking in which they so often indulge (whose prime motive would seem to be cleanliness), and of which, minute as the quantity is, there is enough to serve the diminutive leptothoracian appetite. This is probable; for the salivary glands of ants are well developed, and, as in the case of the honey-bee, may be good food-stuff, even as used in this indirect way. Here, it may be, we have an explanation, in part at least, of

the strange companionships of myrmecophilous insects, as beetles, crickets, and cockroaches, that become guests of ant communes.

The Leptothorax have another source of refection, a good example of which may be induced in an artificial nest by overfeeding the Myrmicas, which, if given sugar and water after a fast, are apt to gorge themselves. In this condition, as they wander about with half-open jaws, minute drops of sweet liquor will be regurgitated. These droplets, as they hang upon the maxillæ and lower mouth parts, attract the Leptothorax workers. They mount the Myrmica's back and imbibe the pendent droplet, at times sharing the confection with a hungry myrmican worker; or the little beggar, from its seat atop of its host's head, will try the effect of the "dinner shampoo," usually with the result that the over-full Myrmica grows complacent and yields to her tiny but canny solicitor the desired sweet.

It was noted that during all these interchanges between the bulky hosts and their tiny affinities the former were continuously complaisant. There were no signs of irritation or resentment at the officious and uninvited solicitations of the guests. They were not menaced, nor seized and held in the mandibles as a mild form of protest or discipline. The Myrmicas rather seemed, as their observer thought, to look upon the little creatures with a gentle benevolence, much as human adults regard children. The friendly antennal salute was always given as they passed and repassed their guests. On the other hand, the Leptothorax attended upon the Myrmicas with a zeal that seemed almost comical. [W. 1, p. 442.] Leptothorax is a genus of cosmopolitan distribution, of heterogeneous instincts, and of catholic temperament,

and therefore well adapted to the varied rôles for which its peculiar size and plastic nature also fit it.

To the necessity for finding food combined with minute size we probably owe the origin of some remarkable associations formed by sundry species. Some of these which live in or near the nests of other species and prey on their larvæ and pupæ, or surreptitiously consume certain substances in the nests of their hosts, have been grouped together under the name of "Cleptobiotic" or thieving ants. [W. 1, p. 528–9.] As a distinctive name the title is apt enough, but the lay reader may be advised that it is not meant to imply moral delinquency, or that thief-ants are offenders above all others; for the act of seizing food wherever it is found and can be taken is common and natural to all ants.

Cleptobiotic ants are small in size and subterranean in habit, and are persistent intruders upon the communes of other and larger species. Their minuteness is their security, and doubtless the source of their peculiar parasitic habit; for it enables them to steal into the galleries and rooms of greater neighbors, and plunder their

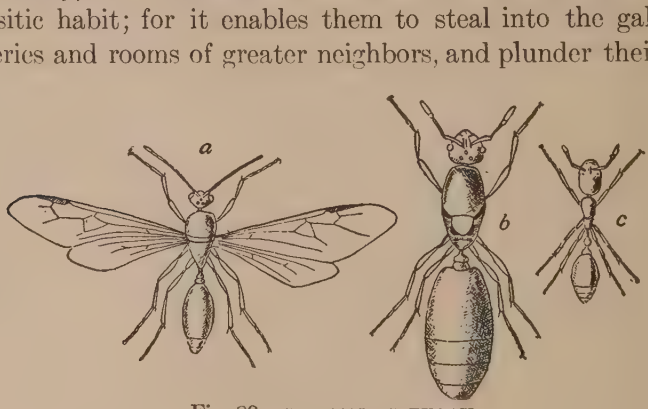


Fig. 89—SOLENOPSIS FUGAX
(After Wasmann)

a—Male. *b*—Deälated female. *c*—Worker. (All magnified)

flocks of larvæ and pupæ. The habits of one species will fairly illustrate the manner of life of thief-ants generally. *Solenopsis fugax* (Fig 89) is a European species

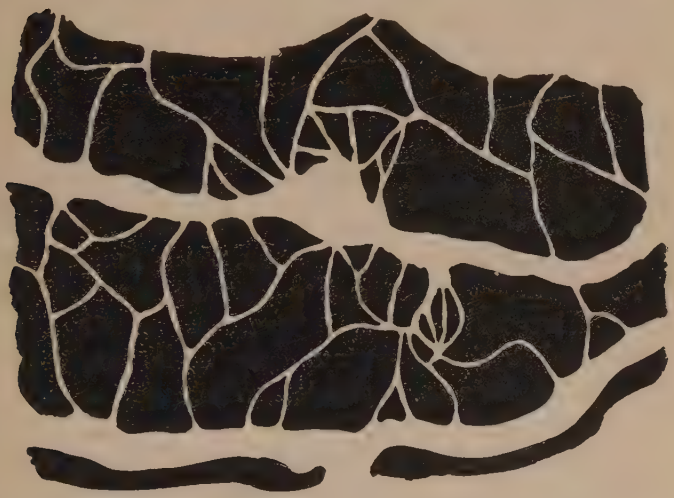


Fig. 90—SECTIONAL VIEW OF HOST-ANTS' NEST, SHOWING THE GALLERIES WHICH THE THIEF-ANTS ENTER
(Wasmann, after Wheeler)

with minute yellow workers, and large black males and females. The way in which it establishes itself within the boundaries of a host is shown in Fig. 90 (reproduced from Wheeler's copy of Father Wasmann's drawing), where its minute galleries, in the sectional view, are seen threading the storied commune of *Formica pratensis*, and opening into the far broader chambers and tunnelled roads of the host. Solenopsis is able to maintain an independent colony and conduct her predatory raids from a distance, but the greater ease of action doubtless attracts it near and nearer and even within the bounds of its host,

Stealing along their tenuous subways, scarcely larger than a lady's knitting-needle, they enter a Formica nursery, where a bunch of cocoons has been stored in fancied security. These they mount, perforate, cut the included pupæ to pieces, and bear the parts away in their mandibles or absorbed within their crops.

Janet observed their method in an artificial nest of *Solenopsis fugax* and *Formica rufibarbis*. He fed the former daily about ten cocoons of Lasius queens, placing them near the formicary gate. Soon the little thief-ants appeared. From ten to thirty—so small they are—would climb upon a single cocoon, which ere long was dotted with minute perforations that at last united in a rift that exposed the contents. Then the fierce lilliputians fell upon their victim, cut into it, sucked its vital juices, and tore it into minute piecelets, which they bore into the nest interior.

One wonders how all this thieving and killing can go on unnoticed and unavenged by the Formicas? A glance at the diagram will show that the diminutive avenues of the aggressors are a secure refuge for them, into which the Formicas could not follow, even if they were detected. Moreover, such an experienced naturalist as Doctor Forel is inclined to believe that, when the two species chance to meet, the minute size of the thief-ants makes them invisible to their hosts, so that the burglarizing and murdering may go on unnoticed. How that could seriously affect the situation, in view of the antennal sensitiveness to other distinctions, does not clearly appear. Besides, small as they are, the thieves are armed with formidable stings, and are so numerous that they are antagonists not to be despised.

It must also be remembered that the secret and

stealthy method of these marauding mites is not calculated to arouse the ire of the Formicas and marshal them for resistance, as would, for example, the raid of a battalion of slave-makers. They have the real kleptic faculty of human robbers, and steal softly to their work. Having acquired the protective nest-odor of their host, they doubtless pass in and out, not unchallenged, but with impunity. In America, *Solenopsis fugax* is represented by *S. molesta*, a minute yellow ant with yellow queens and dark-brown males. It is widely distributed, and Professor Wheeler thinks that its habits are substantially the same as those of its European congener. [W. 1, p. 533.]

It remains to speak of that form of consociation which Wheeler has classified as Plesiobiosis, the "double nests" of Forel, and which Wasmann has designated as accidental forms of compound nests. This comprises cases in which two, or rarely more, colonies of ants of different species occupy galleries and seemingly have established formicaries in close contact.

Among these ants Professor Wheeler groups several species observed by this author. The fœtid ant (*Forelius fœtidus* Buckley—*F. maccooki* Forel) is a small, yellowish dolichoderine ant which lives amicably within the nest boundaries of the Texan agricultural ant. Numbers of these ants were seen frequently travelling in long lines, in single or "Indian" file, across or near the nests of the agriculturals. Usually their route was upon blades of grass growing on those nests that were covered with needle-grass (*Aristida*), or along low tufts of grass on the margin of the disk. The agriculturals took no notice of their tiny neighbors—at least, never interfered with them — and the two species seemed to be upon the most friendly terms with each other. [McC. 3, p. 202.]

Another case of this sort of consociation is that established between the occidental ant of Colorado and a small species of Dorymyrmex (*D. pyramicus* Roger var. *flavus* McCook). There was scarcely a formicary of Occidentalis that did not have upon its surrounding clearing one or more species. Usually there were two or three nests, sometimes four, located upon different parts of the pavement. These were small moundlets of fine soil, surrounding a central opening that led into an irregular series of galleries and chambers. [McC. 5, p. 155.] The insects are small, active, irritable, intensely pugnacious, and courageous. The manner in which these little fellows bullied and badgered their occident hosts was amusing and, indeed, amazing. Examples of this belligerency are given and illustrated in Chapter X—"Warrior Ants and Their Equipment for War."

Of the nests of six species of true ants found parasitic upon the nest of Occidentalis, I found colonies of the Sanguine slave-maker on three separate pavements. The gates were on the clearings not far from the central mound, and on exploring one occident nest the formican galleries and rooms occupied a goodly part of the interior space. The number of ants and slaves in these compound nests was quite large, judging from those in sight, yet there was seen no antagonism to these guests on the part of the occident hosts. The species were not greatly unequal in size, but the disparity in numbers and in belligerent efficiency was such that the occidents could have exterminated the Sanguines and their kidnapped retainers. The auxiliaries of *sanguinea* were *Formica Schaufussi* and a small black ant which Wheeler thinks was one of the Western varieties of *F. fusca*.

The most curious and interesting of these parasitic formicaries was that of a large blue-black Formica. I first found its galleries at four feet below the surface, and thereafter traced them to within four inches thereof. The Formicas occupied the central and eastern part of the excavation. The architecture was less regular than that of Occidentalis, which may have been the result of necessity rather than natural habit, but showed arrangement in stories. The rooms communicated with one another, and were crowded with workers, callows, and grubs. The galleries and chambers were placed side by side and in the midst of those of the occident ant. One of these, located in the heart of the nest and full of larvæ, was just above and flanked on each side by granaries of Occidentalis packed with seeds. Another opening higher up was surrounded by occidents' rooms. I have rarely seen so curious a study as that presented by these interblended interiors. [McC. 5, p. 154.]

My miner assistant might well raise the query, "Which of these fellows jumped the other's claim?"—the Colorado vernacular for, "Who was the intruder, and who the original possessor?" The arrangement and relative positions of rooms and galleries led me to infer that there had been a contemporaneous growth. The two queens established their original cells in vicinity. In time, mutually expanding their bounds, they approached each other, and thenceforward held the ground together. By what peculiar gift or condition were the two species able to so guide their engineering that they never conflicted? Or, did they conflict?

I could find no traces of intercrossing of openings or impinging of chamber walls. Closely as these approached, they seemed to be structurally distinct. What

legal conflicts, what local battles and bloodshed, have resulted from trespasses on boundaries made in the gold and silver mines of the human neighbors and fellow-miners of these insects, old-time Coloradoans know too well. Were the emmets more peaceable and tolerant of one another than the men? Or, would the secrets of their subterranean abodes, if given to natural history, uncover scenes of dreadful conflict and death?

As the excavations uncovered the interior of the great nest, nothing appeared to indicate a state of warfare past or recent. As pick, trowel, and knife exposed the rooms, both species were surprised in the midst of their ordinary duties, and showed unmistakably that they were wholly engrossed in peaceful industries. But when, by some careless stroke of the tools, rooms or galleries of the two species were forced together, or when the crumbling earth precipitated the insects into a common trench, then the polemic possibilities appeared. Then blacks and reds grappled in hot strife and fought with fury. The powerful sting of the occidents was brought into service, as the combatants rolled, struggling, in the soil, and the sharp mandibles wrought like a French guillotine, as witnessed by the decapitated trunks of the Formicas quivering in the trench, leaving at times the severed head still clinging to its antagonist by jaws clasped in the rigor of death.

These battles seemed to confirm the fact indicated by a study of the architecture, that the status of the Formicas in this compound nest was one of peaceful parasitism. The occidents plainly tolerated their neighbors, for manifestly they had the power, had they been so inclined, to drive them out or destroy them.

CHAPTER XIV

THE FOUNDING OF SLAVE-MAKING ANT COMMUNES

ANTS are unique among social insects in the practice of a form of slavery. Bees and wasps, as far as known, show no tendency thereto. Indeed, their physical condition and manner of life seem to bar the way to the development of such a type of co-operative citizenship, while, on the other hand, the habit of ants rather invites it.

In this characteristic we have another suggestion of those tendencies of human society which appear in emmet life. As far back as run the authentic records of our race, we trace some form of slave-holding. The Abrahamic type, as uncovered in the Old Testament, was little more than civic adoption, a kind of tribal "naturalization"—to borrow a term from American customs. Ancient Egypt had a far severer sort, as seen in her remarkable mural history, preserved even to this day in the inscriptions and paintings on the inner walls of her tombs, and confirmed by the Bible story of the Hebrew bondage.

The slavery of classic Rome and Greece, though most cruel in many of its features, had some mitigations; at least, it did not close and seal the door of hope, but kept an open way for its "freedmen" to become honored and influential citizens. It lacked, as did most early forms of human bondage, that racial bar and taint which

was one of the worst features of American slavery. Our British forebears, to whom we owe our views of both civil liberty and chattel slavery, were at one with all Europe in holding Africans as the lawful prey of white men, and quite outside the pale of the common right of man to liberty and independent life.

One needs this bird's-eye glance at this phase of human society as he takes up a somewhat analogous feature of certain ant communes; for our conception of ant "slavery" is colored by the current meaning of the word as derived from our own use and wont. It is not, indeed, an inapt term as applied to emmet communes, if one regard the usage of men in the whole course of social history; but it is a different thing as interpreted by one's preconceptions of slavery as lately existing in the United States.

In point of fact, there is no trace of such slavery in the relation. What one sees in a so-called slave-holding ant commune shows no involuntary servitude, nor any conditions substantially different from those obtaining in ordinary ant communes, except the presence of two distinct species. These, in their bearing toward each other, give no signs of superiority or subordination. It is a co-operative citizenship, whose duties, in one type of commune, are more sharply differentiated between the two classes of citizens than in the other, but wherein all are apparently equal and free, although one class has been kidnapped in infancy and reared in its abductor's home. In so far, no further, they may be ranked as slaves.

There are several species in America that may be classed as slave-holding but all may be ranged under two types—the SANGUINE and the POLYERGINE, so named

from the species *Formica sanguinea* and *Polyergus rufescens* that respectively represent them. In communes of the Sanguine type the dominant species preserves all normal ant characteristics in full potency, and cooperates with the auxiliary or "subject" species in civil responsibility and labor. In the Polyergine type of colony the dominant species, *Polyergus rufescens-lucidus*, the "Shining slave-maker," has lost all disposition and even ability to any service but that of conducting periodic predatory raids and supplying the commune with captives.

It seems an odd coincidence, in view of the preference for African slaves among men, that the ants most affected by the slave-makers are the dark species and varieties, particularly *Formica fusca* and its glossy-black American variety *Formica subsericea*. Both the Sanguine and the Shining slave-makers victimize these species more freely, perhaps, than any others. This is due, doubtless, to their greater feebleness and comparative timidity, as well as their adaptability to associated service.

We are now to undertake an inquiry into the natural conditions out of which this interesting phase of emmet life may have arisen.[1] In so doing, it is well to remember that our search after the origin of habit must always be more or less like progress up a blind alley wherein we are sure to come to a point where a blank wall faces us. For, follow back our inquiry as far as we may by observation and experiment, and by reasoning thereupon, we come at last to the mystery unsolved, and seemingly unsolvable by our natural methods—how

[1] For a study of the habit itself, see *Nature's Craftsmen*, chap. v.

arose the *first* individual and the *first* action of the series? Nevertheless, one must push on, by virtue of his insatiable thirst after the final cause of things, as far as he may.

The first decided step toward the truth in our study of the phylogeny of the slave-making habit among ants was made by Prof. William M. Wheeler. During the summer of 1904, while studying ants among the Litchfield Hills of Connecticut, Professor Wheeler made the brilliant discovery that the female of *Formica difficilis-consocians*, after her marriage-flight, habitually seeks a weak and probably queenless nest of *Formica Schaufussi-incerta*, and thereupon founds a colony of her own species. The host-commune, the Schaufuss ant, belongs to the group whose native temperament seems to adapt them to serve as auxiliaries, and a depauperate and queenless condition favors the welcoming of a queen, even though an alien. On the other hand, the Consocians female is of characteristically diminutive stature, and thus physically disqualified from the usual rôle of solitary queens—the rearing of an independent commune. Thus mutually adapted for union, an alliance is formed, and the first step of a mixed colony is made.

Now follows a strange and interesting history whose bearing upon our subject readily appears. The Consocians queen drops her eggs. The Incerta workers, true to their instinct, care for them and rear them to maturity. Ere long they equal their nurses in number, and soon exceed them. As there is no natural source from which to recruit the ranks of the host-species, in the ordinary course of communal life and service the original founders gradually decrease, until all have died out. There remains then Consocians commune pure and simple.

This method of founding a colony the discoverer called "temporary social parasitism," and he inferred that a number of these mixed colonies known to exist, and which had been thought to be abnormal or accidental consociations of two species, were in all probability merely cases of temporary parasitism. And he predicted that various species of the *Formica rufa* group would be found to establish their colonies after the manner of *F. consocians*—that is, by the aid of some one of that group most affected as auxiliaries among slave-makers.

It seemed to follow, as an almost necessary conjecture, that this might give the clew to the true phylogeny of the slave-making or dulotic habit first discovered by Pierre Huber. He therefore entered upon a series of remarkable experiments, from which we may conclude that the method, as it occurs in nature, has been uncovered. A strangely interesting story it is. [W. 2, pp. 33–105.] Twenty-one experiments were made with young queens of *Formica sanguinea* (of the prevalent American variety *rubicunda*) and artificial colonies of *subsericea*, a widely distributed American form of *Formica fusca*, which is commonly found as an auxiliary in slave-holding communes. Two of these were partially and ten completely successful. The following accounts of two experiments will show both the professor's methods and the results.

The artificial nest used was divided into two connected chambers, one illuminated, the other darkened. Herein was placed, within the dark chamber, a colony of twelve large Subsericea workers and a number of worker cocoons. To these a female Rubicunda was introduced.

Some of the workers snatched up cocoons and fled

into the light chamber, while others fell upon the stranger and began to tug at legs and antennæ. The queen was passive for a few minutes, then aroused herself, shook off her assailants, and began to prance back and forth in the chamber, pouncing on any worker within reach. Having slain two of these in quick succession, she began to collect cocoons and put them in a corner of the nest. When eighteen had been assembled, she mounted the pile and stood guard over it, with mandibles wide open and threatening.

Meanwhile the Subsericeas had hastened with the remaining cocoons into the light chamber and plugged up the door with earth-pellets. For two days matters thus stood, Rubicunda perched upon her looted cocoons, and the black workers keeping to their own apartment. At night, however, there must have been a sally and a combat; for early next morning (July 9th) the queen was dead, and her captured cocoons were replaced with the others. The victors' formic-acid batteries had wrought their subtle aim, for their adversary's large body was not mutilated. Death resulted from poison.

Let us now mark a more successful experiment. Into a colony made up of thirty-three Subsericeas, one hundred and fifty cocoons, and a few larvæ, a Rubicunda female was placed. The workers were thereby intensely excited, and, seizing their cocoons, rushed into the light chamber. Two who advanced to assault the stranger, as a sort of "forlorn hope," were shaken off and one slain. During this conflict other workers stole back into the dark chamber to secure more cocoons, which were stowed in the remotest corner of the light chamber. Meanwhile the queen's excitement had much increased. In the interval of four hours she had killed five mor

workers. She entered the light room, raided the cocoon stores, and captured and transferred them, thirty-six in all, to the dark room. Between trips she stopped twice to attack and kill workers that ventured near.

Now she retired to the dark chamber, and collected her booty into a compact pile. This was not done without some opposition, for two Subsericeas slipped by her, deftly snatched up cocoons from the fringe of the pile, and carried them back to their own quarters. Their venture cost them dear, for Rubicunda in the end detected them and slew them ruthlessly. She was highly excited, and pranced vigorously about the floor—that is, she moved in a jerky way, taking a few steps in one direction, then wheeling quite around, took a few steps more, her antennæ waving eagerly, and her whole body seeming to throb with passion.

By the next morning (8 A.M.) only two Subsericeas remained; but they had managed to regain thirty cocoons, which the survivors were guarding in a remote corner of the light chamber, while Rubicunda stood guard over a bunch of them in the dark chamber. Two and a half hours thereafter she sallied forth and recaptured all but six of the workers' cocoons, and added them to her own store. However, she had not forgotten the scant remainder, for soon she secured four more, and early in the afternoon another was captured.

The two workers wandered about forlornly, seemingly dejected at their hard fate. One came into the dark room and approached the queen, possibly to test her willingness to come to terms; but she opened her mandibles threateningly, and the peace ambassador fled. During the night this and one other survivor were killed, and the last cocoon was added to Rubicunda's collection.

She was now, indeed, monarch of all she surveyed. She had wholly extinguished the colony of adult Subsericeas brought up under and devoted to the old régime, and was in a position to rear around her from her kidnapped pupæ and larvæ a commune to the manner born, who would accept her headship and build up a loyal citizenship.

She seemed to take a greater interest in the pupæ than in the larvæ—naturally, perhaps, because from the former would come her first effective helpers. And they soon began to come. That night (July 16th) five callow ants appeared, and one larva was partly eaten. Had it been sacrificed to the queen's appetite, or had it died first? That afternoon she was seen opening a cocoon to release a mature pupa. She used her fore and middle feet to hold the stiff silken cocoon-case, while with her mandibles she tore it open. The youngling aided her by thrusting out legs and antennæ, and was soon drawn through the hole, to begin the life of an imago novitiate.

Now the work of delivery went briskly on. Whenever the nest was uncovered, Rubicunda might be seen either opening a cocoon or removing the pupal envelope from a new-born callow. A week thereafter the whole brood of living pupæ, one hundred and thirty, had been set free, the older callows assisting in delivering their sisters. The queen took the greatest interest in her black family, and they in turn soon began to care for her. They fed her and cleansed her, plying their tongues to her body in the usual shampooing process.

Meanwhile a marked change occurred in her instincts. Instead of resenting intrusion, and rushing to the defence of her brood when the formicary was opened, she slunk away and tried to hide among the workers. She

acted quite like the old queens, who at once fly to the galleries and lower rooms when a nest is opened or lighted up. On July 26th, eighteen days after its beginning, this experiment was ended and the ants turned loose in the garden to shift for themselves.

These two experimental observations which I have thus presented in abstract fairly typify the results gained by the patient and ingenious observer. As he remarks, "the reactions displayed are so definite, uniform, and purposeful, even in artificial nests, that one can hardly doubt that they are similarly manifested in a state of nature."

If, then, we will permit imagination sufficient play to suppose our ant queen expatriated and wandering solitary, we can fairly picture the process by which a slave-holding commune may be established in natural site. Through fa oring chance and native instinct she falls upon a nest of some inquiline species—*Formica subsericea*, let us say. She pushes her way into the room, vestibule, or hall, hoping, mayhap, for a welcome and an amicable adoption. The amazed and alarmed inmates seize their cocoons and larvæ and fly before her into the lower galleries and rooms. To cover their retreat, a few devoted patriots advance to meet and attack the intruder. Her choler rises before this inhospitable reception, and at once her latent war-like and predatory instincts are aroused, and she flings herself upon her assailants. Her superior size, strength, and martial spirit make her a match for many of the unwarlike blacks, and the home defenders are slain. There follows a prolonged quarrel, and the caverns of the Subsericean commune witness a succession of conflicts and manœuvres for the possession of the infant antlings and their nurseries and home.

Rubicunda's maternal instincts have now awakened, and Nature plies them side by side with her martial powers. She seizes and assembles the cocoons and larvæ of her unwilling hosts, who, in turn, by violence and stealth, seek to retain and recover them. Back and forth from the care of the usurper to that of their natural kin the tender and unconscious things are borne, until the extraordinary conflict is closed by the conquest of the Subsericean domain and the death of all its original owners. Here, in this lowly sphere of life, as so often it has been in human affairs, violence and usurpation have prevailed, and a new commune is founded upon war and robbery.

For this is indeed the foundation of a new emmet commonwealth. Fierce and remorseless as Rubicunda has been to the adult blacks, she is not untender to their offspring and kin. Her interest in the young brood deepens with the advent of peace. She feeds the larvæ, cleanses them, dandles them, shifts the cocoons from place to place, as though to give them exercise or to better the location. At last—and it is a rare event in the history of this budding commune—the queen-mother marks the signs of maturity within the tough silken case that encloses a pupa. With hereditary gentleness and skill she plies her mandibles—as facile an implement for this delicate surgery as it is dreadful in fight—and delivers from the cocoon-case, Nature's detached womb, a living imago ant! The delicate membrane that still encloses it is removed with even a daintier touch, and there appears the first auxiliary citizen of the new commune, full grown and full panoplied for civic duty. It is yet in callow antlinghood; its shelly "skin" will harden and darken; but its instinct for the

service of citizenship is full blown, and at once it joins its foster-mother and queen in helping into freedom its enswathed sisters.

Steadily the number of callows grows. Every newcomer adds to the working force. All are welcomed by both queen and fellows. To her, all are children; to them, she is a common parent and sovereign, as loyally and lovingly recognized as though they had been the fruit of her own ovaries. At last all the captured brood have matured, and have joined the working-band, and the rooms and galleries (the houses and highways) of the new city are astir with busy life.

Soon Queen Rubicunda begins to function as mother. The wee white eggs which she drops are cared for by the black workers and nursed into life. They are young Rubicundas! Their ruddy skins are in sharp contrast with the black skins of the Subsericean auxiliaries. It matters not. There is no distinction. They are citizens, all, of one commune; sisters, all, of one family; inheritors, all, of one nest-odor—the real badge of a common citizenship.

Meantime Rubicunda has undergone a noteworthy psychical change. The instincts of warrior and sovereign gradually yield to those of mother and founder. She screens her own person, since her life is needful to perpetuate the colony, and for the same reason permits herself to be guarded and cared for by the workers. Thus the commune is founded and the normal activities of an ant city grow up and go on.

The case here given of the way in which Rubicunda founds a colony is a typical successful one. But for every such success there have been a multitude of failures. And that is well for other tenants of the earth; for, con-

sidering the vast number of migrants from one nest at the marriage-flight, were not the losses of life enormous our world might be transformed into an ant-hill! As it is, all males perish, and comparatively few females gain a foothold upon active communal life.

But we are yet far from accounting for the origin of that feature in the slave-holding ant's habit which, perhaps, is the most striking to the ordinary student of animal behavior—*viz.*, the issuing forth in martial bands

Fig. 91—WORKER ANTS DEPORTING CAPTIVES OR THEIR FELLOWS DURING MIGRATION

to sack and despoil neighboring communes of other species, and to transport them to their own nest to enter upon a state of servitude (Fig. 91).

One needs to keep in view the fact that the primary aim of a Sanguine slave-maker's raid is not to recruit the tale of laborers, but to supply food. The acquisitive instinct which in seed-eating ants, as Pogonomyrmex and Pheidole, is expressed in storing grains and oily seeds, has outlet in Sanguinea-rubicunda and her kind in the accumulation of the carnivorous food of which all ants are fond, and which is stored in the compact form of the immature young of plundered species. Doctor Forel observed that his *Formica sanguinea* colonies reared but a small portion of the cocoons given them as a test. One formicary to which he gave "a fabulous number" of

Formica pratensis cocoons during the course of a summer failed to raise a single one. [F. 1, p. 259.]

Yet there is apt to be, and commonly is, a remainder that gets adopted. And there will always be among the imported cocoons some that are near maturing, and actually mature before they are needed for food. These imported imagines are born into the native nest-odor, and are thus qualified for acceptable citizenship: a status acquired, as Miss Fielde has shown, within the first three days following emergence. [Fd. 2, p. 320.] These drop naturally into the services of callows, as though they were at home, and they make up the contingent of consociates in mixed colonies, and of auxiliaries or slaves, which in the Sanguine type of commune is apt to be less than half the whole number of workers. No sexed forms are tolerated among these abducted and adopted citizens, and therefore no rival queens with conflicting claims disturb the communal peace.

These facts are now well established, and they are substantially those which Darwin predicated as the basis of his theory of the origin of the dulotic habit in *Formica sanguinea,* and which long ago were approved by such master myrmecologists as Forel and Wheeler, and such a philosophical naturalist as Lord Avebury.

The acquisition of the habit of raiding in column has yet to be accounted for. Every individual ant is, by the primary necessity of feeding itself and others, a natural forager. The worker is hardly well out of callowhood ere the strong instinct of communal beneficence, fortified no doubt by personal hunger, impels it forth from the home gates to pick up whatever edible it may happen upon. The emmet "conscience" knows no law of *meum et tuum,* and these solitary plunderers

may be seen everywhere afield. A fallen and bruised apple or peach or a dropped bit of sweet will at once demonstrate the presence of these universal foraging scavengers and robbers. Herein nature has planted in the individual ant the predatory habit upon which to build up such an expedition in column as the raids of Sanguinea-rubicunda disclose. This is the first stage; we proceed to the next.

The wars of ants, as has been shown, usually arise from the quarrels of a few—often, perhaps, stragglers—over some treasure-trove. One after another joins the fray; messengers fly to the respective nests; and soon numbers of recruits, all throbbing with martial fervor, are thronging from either communal centre to the battle-field. This tendency to march in file and to mass for defence and attack, and, indeed, for other matters of common interest, is ingrained with most species, and seems to strengthen as the colonies grow.

With the honey-ants of the Garden of the Gods, as the author has shown, such an assemblage occurs before the evening excursion after honey-dew. [McC. 5, p. 24.] Toward sunset the workers begin to gather around the single crater-like gate of the home mound. Soon the summit is covered with the yellow adventurers. At last the break is made, and away they go, keeping well together until the column breaks into sections and integers at the foraging-grounds, a thick clump of scrub-oak bushes. Quite the same phenomenon attends the evening outbreak of the cutting ants of Texas. [McC. 6, p. 243; 10, p. 34.] When the chippage used to barricade the gates has been removed by the smaller workers, the leaf-cutters push their way out, and pour forth in squadrons, a great army, and as such march to the chosen

foraging-ground. Indeed, something of the same sort may be seen, though in cruder and less-concerted (if at all concerted) form, in the daily raids of the mound-making ants in their excursions after the honey-dew of aphides upon the trees growing near by their ant cities.

Enough has been said to show that the movements of ants in column, especially for a hostile and predatory purpose, is a tendency, not to say a trait, that appears in many species. To be sure, it is reasoning *per saltem*—and doubtless a wide vault, indeed—to infer from such general tendencies the development of a trait so thoroughly fixed and admirably ordered as the predatory raids of our Sanguine slave-makers. But in the present state of emmet ethology, some such tentative inference may be justified, until wider and minuter studies shall enable naturalists to fill up the gaps in our knowledge. One may have good hopes that this will yet be done, as prying naturalists go forth to their true aim,

> "And take upon 's the mystery of things
> As if we were God's spies."

For surely the hidden things of nature must all be brought to light ere the divine call of man to the universal inquisition after truth shall be fully answered.

It is significant that while the black auxiliaries are given a full share of the commune's diverse services, their red superiors labor with them side by side, and seemingly with full efficiency and activity. That the Rubicundas must be sensible of the advantage of strengthening their working force may be conceded, and also that this may have been in some degree, at least, a factor in determining their kidnapping excursions. But, manifestly, dependence upon their imported labor has in

nowise reacted unfavorably upon themselves. They have not deteriorated, but retain their full generic equipment as builders, nurses, foragers, and workers generally in all the diversified duties of ant citizenship.

This is in marked contrast with what has occurred in the Polyergine type of slave-makers. There the workers have lost all characteristic qualities except the martial. They have developed into mere vital kidnapping machines, with those soldierly capacities needed to make them effective. As slave-catchers, robbers, and fighters they are highly efficient; but they lack the power to carry on the ordinary and needful affairs of a commune. They remind one of those human tribes whose males function as warriors only, and leave to their slaves and women the entire work and burden of the commune. Indeed, with the Polyergines, degeneration has gone so far that they depend upon their slaves not only to procure food, but to bestow it. So abject is their estate that they cannot feed themselves, and, lacking the offices of their slaves, die of starvation. However, as with the Sanguines, no sexed forms are permitted by the Polyergines other than of their own species.

It is not the writer's purpose to give here a detailed account of a slave-maker's raid. He has given that elsewhere. [McC. 7, p. 71.] But it may be ranked justly among the most interesting incidents in the history of insects whose ethology presents some remarkable analogies to our own social manners. Were we to take a brief view of such an event, what points would fix our attention? We would note the organization or communal action implied in the impulse that sends the raiders forth; the scouting that must precede a sortie in order to locate the quested objects of assault; the com-

munication of antennal signals; the drafting of the red warriors from whom the attacking contingent is drawn, and the gathering of the black auxiliaries to tarre on the belligerents, though in sooth they need no such "very pregnant and potential spurs." We would note the forward movement; the ordered march; the vanguard action with skirmishers from the assailed commune; the fierce scaling of the Subsericean barricades, and the plunge into the cleared ways. We would see, perhaps pity, the futile efforts of the besieged to enguard their commune gates; the flight of the inmates, bearing their young, from the pillaged nest; the woe-begone groups of refugees hiding in the vicinage; the little knots of combatants scattered here and there around the field, the melancholy tailings of a lost battle; the maimed, the dying, the dead scattered here and there. We would follow the return column of raiders laden with their booty of larvæ and pupæ, and occasionally adult blacks, as tender-hefted in this office as they had been ruthless in assail; the heartening of the pillaged Subsericeans as they see their foes retiring; the occasional rallies and rear-guard attacks to recover some of the spoil, and not always in vain. We might feel, perhaps, a flush of indignation at the welcome of the well-guerdoned spoilers to their home commune, with every token of satisfaction (except noise!); and, on the other hand, a touch of sympathy at the gradual return of the refugees to their desolate city, with the young saved from the common spoilage, to take up again the rôle of communal life. All these incidents unite to form an event unique and of transcendent interest.

A faithful description thereof, were it published with the bare substitution of human names, would need scant

revision to serve as an accurate account of a scene in the warfare and predatory expeditions of men. One who has viewed both events—the storming of an ant-hill and the assault upon a fortified town—will vouch for the striking resemblances that appear throughout the entire series.

Perhaps those whose sympathies have been keenly enlisted by the author's recital of the cruelties and sufferings attending the wars of slave-making ants will not deny the plea for peace, universal peace, as the ultimate end of civilized men; and meanwhile the mitigation, in every attainable way and measure, of the awful rigors of war as now tolerated in a world still so largely in a state of nature, unhallowed by Christian grace and truth.

CHAPTER XV

PROBLEMS OF SANITATION AND PERSONAL BENEVOLENCE

THE sanitation of cities and homes has come to be one of the most important problems of human government. It is only recently that it has been considered with scientific method and thoroughness, and that society has addressed itself to its solution with adequate vigor. How is it in ant commues? Their method of preserving the public health is summed up in one word—cleanliness.

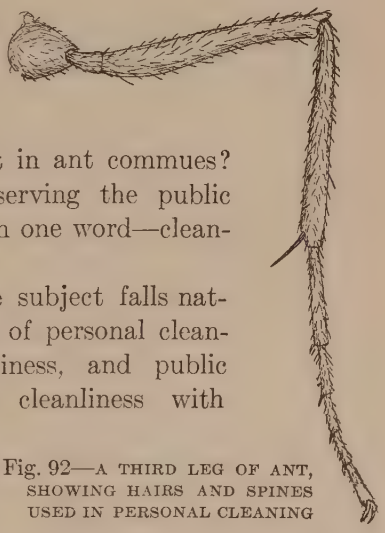


Fig. 92—A THIRD LEG OF ANT, SHOWING HAIRS AND SPINES USED IN PERSONAL CLEANING

Our treatment of the subject falls naturally under the heads of personal cleanliness, parental cleanliness, and public cleanliness. Personal cleanliness with every ant is a passion. As much time is given to cleansing the person as is required, and no work is so urgent as to interfere with that. Nature has abundantly provided for the support of the habit which she has implanted, by the gift of certain implements.

The legs (Fig. 92), which are clothed with hairs, bristles,

and spines that are likely to take up dust, are scraped against one another to remove the coarser grains of dust, as a man might scratch a shin-bone with the calf of an opposite leg. Then they are drawn alternately through the jaws, which, with the saliva of the mouth, act as a sort of scraper and sponge for removing finer particles. Again, they are used to comb the head and antennæ, for which they are provided with pairs of tibial combs, coarse-toothed and fine-toothed, of which our own toilet articles are a close likeness.[1]

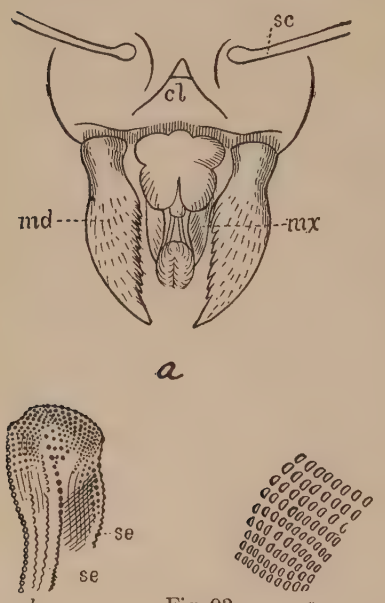


Fig. 93

a—View of out-thrust tongue of agricultural ant from above. *b*, *c*—Enlarged views of the "bosses or bulbs" on the tongue. *se*—Serrate edges. *md* — Mandible. *mx* — Maxilla. *sc*—Scope of antennæ

In addition to these is the tongue (Fig. 93), a rasped organ similar to that of dogs and cats. How effective this is for cleanliness in these domestic animals most persons know. It is equally serviceable with ants. It is this organ that is used in those parental acts of cleansing committed to the nurses. The larvæ, from the time they are taken in charge until they pass into the pupa

[1] *Nature's Craftsmen*, p. 67.

stage, are so freely sponged with the rasped and moist tongues of their caretakers that there is little chance that dirt or parasite or fungoid germs shall remain. Even after adult life is achieved the friendly offices of cleansing are exchanged between neighbors, and one will see a mutual shampooing among the ants in his artificial nests.

The need for personal cleanliness is greatly increased by the underground life of ants, which subjects them to attacks of sundry vegetable moulds and parasitic insects. Some of my experimental colonies have been destroyed by mites (Fig 94); and it was pitiful to see the little creatures' struggles to protect themselves from the invasion of the hordes of minute parasites, against whose attacks they were seriously, even fatally, hampered by the artificial conditions of their unnatural life. The value of special armature of legs and jaws and tongue, and the habits of ceaseless cleanliness engendered by their use, were mightily emphasized by one's observation of this unfortunate episode in the career of these imprisoned colonies. The thought occurred that the habit of feeding upon fungus growths, and the cultivation of fungus gardens in the Attidæ (cutting ants), may have arisen from the use of the tongue and jaws in freeing themselves and their commune from the attacks of vegetable moulds.

The location of the larvæ is often changed, a useful sanitary precaution. The baneful effects of sudden changes in temperature and humidity are met by shifting the antlings nearer the surface or farther within the cone. For such manipulation among the mound-builders their elevated and perforated structures are well adapted, and for this, in part, may have been de-

veloped. In small nests one may observe this by turning over a flat stone on a bright spring day or in early autumn, when the little heaps of white larvæ may be

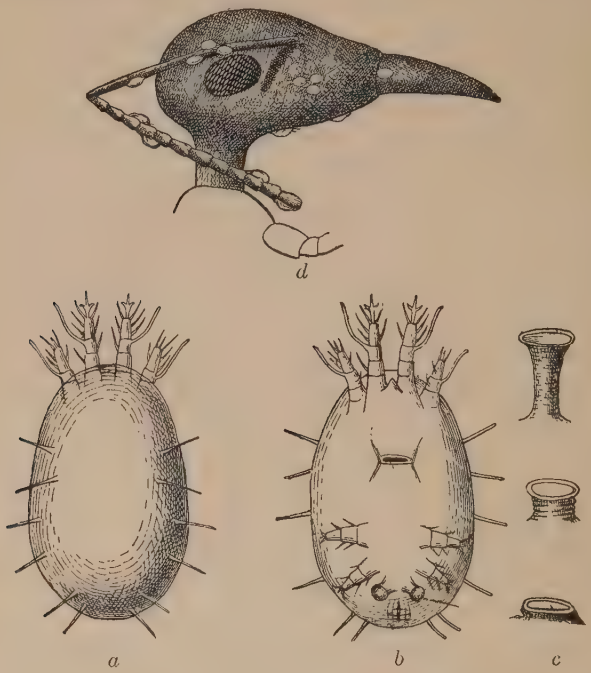


Fig. 94—MITES THAT ATTACK ARTIFICIAL NEST OF HONEY-ANTS (GREATLY ENLARGED)

a—Dorsal view. *b*—Ventral view. *c*—Suckers on the same in different degrees of extension. *d*—Mites upon the cheek of a honey-ant

seen lying in the top galleries next the stone, whither they have been brought from the underground rooms for the sake of greater warmth and health.

Ants enjoy these personal ablutions, as one readily sees who closely observes them either in nature or in artificial nests. While engaged therein they put them-

selves into sundry odd positions; at least, so they seem to an onlooker, although quite similar attitudes may be seen in cats and dogs when giving themselves a tongue-brushing. In mature imagohood they are seen frequently sponging and combing themselves. Dust and impurities of whatever kind they cannot abide, and are uncomfortable until rid of the defilement. They are continually in contact with muck and mud and dust,

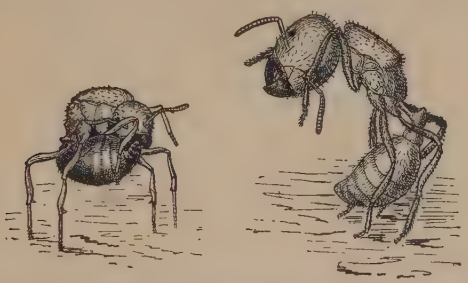


Fig. 95—ANTS CLEANING STINGING APPARATUS AND BRUSHING BACK-HAIRS OF THE HEAD

living as they do on and under the ground in earthen caverns and cells. Yet who ever saw one looking untidy and unkempt? (Fig. 95.)

"As tidy as an emmet" would be an apt proverb, and it would apply with equal truth to bees, wasps, hornets, yellow-jackets, and other insects. If it be true that cleanliness is next to godliness, our tidy emmets, not here and there a rare example, but one and all, would be fair candidates for canonization, and no *advocatus diaboli* could challenge their record successfully. Perhaps it would be impossible for human laborers, in any conceivable industrial condition, under any form of government, to approach even afar off the habitual cleanliness of working ants.

But one who has mingled much with working-men and closely observed their manners might venture to suggest that a much closer approach to these exemplary characters is entirely practicable. That it would greatly enhance comfort, health, good looks, and that sense of respectability and personal purity that goes so far to elevate human nature is hardly to be doubted. But could employers afford to give their workmen the time needful to effect such personal cleanliness? Would the increased efficiency coming with the higher quality of manhood and womanhood thus attained sufficiently increase the product and the value of the work to justify the sacrifice? One asks such questions glibly enough, but how shall he find a practical answer?

An important item in public sanitation is ventilation. Since ants are apterous, no such mode of agitating the air and producing a current by rapid wing movements is possible as practised by bees and hornets. The former have squads of winged ventilators just within the hive gate, the latter just outside the door. How ants produce a like effect is not yet determined. As most of them domicile in the ground, they are not as likely to suffer from heat as honey-bees and hornets. But although their consumption of air is not great, one would suppose that such crowds of creatures living in such confined quarters as we have described would soon vitiate the atmosphere and make necessary some sort of purification.

Perhaps this is secured among the mound-making ants by placing the city gates most numerously at the base of the cone. Through these there is doubtless a constant or sufficient current of air passing out of the open doors distributed along the sides and upper parts

of the mound. Moreover, there is an extensive system of underground galleries reaching, in one case at least, sixty feet from the central mound, and these are probably ventilated through the basal gates. But it is not so easy to see how such vast structures as the nests of the agricultural and occident ants can be ventilated through their single gates.

The problem of drainage must be a pressing one in ant communes, and its practical solution is an interesting study, although one must depend more upon reasonable inference than deduction from known facts. That many nests must be inundated during long and hard rains is inevitable. That their inmates can endure a goodly period of submerging without drowning is known. But some method of warding off or carrying off or absorbing the excess of water in severe rains and floods seems to be required.

The conical shape of such nests as are built by mound-making, occident, and rufous ants, although perhaps primarily due simply to the natural action of gravitation, must aid in keeping the inmates dry by shedding the rains as do our own peaked house-roofs. One would think that placing the bulk of the gates near the base of the mound would be disadvantageous until he remembers that the large space above, with its numerous series of interlacing galleries and rooms, gives an admirable refuge for the commune's infant charges. There they may be deported in heavy rains and kept in good condition.

In the case of such single-gated cones as those of the occident ants, the danger of flooding is less; and, moreover, there, as with the flat disks of the agricultural ant, gate-closing can be resorted to. At least one example

of such a mode was observed before a storm, the gate being shut up by pebbles, earth-pellets, and chippage precisely as at night. One agricultural ant-disk was watched during a rain. The harvesting workers rushed for the central gate from all points of the circle, over which the water was beginning to gather, and in a moment the gateway was choked up by the crowd of insects massed on and around it. I did not think at the time this was done with the intention of closing the gate and shutting out the water accumulated in the plaza, but it had that effect. Possibly it may have been intended so.

It is probable that in such weather conditions the rain that enters the nest gradually descends through the storied rooms and galleries and is partly absorbed during descent, and at the bottom of the nest is gradually taken up by the underlying ground. It may even be that the lowest cavities, both chambers and galleries, are left uninhabited to receive excess of intrant rains, or are vacated during wet weather, that they may serve as a sort of temporary relief reservoirs.

Livingstone [Lv. 1, p. 353] notes that the ants of Dilolo (South Africa) manage to preserve their communes upon plains where water stands so long annually as to allow the lotus and other aqueous plants to mature. When all the ant horizon is submerged a foot deep they occupy little houses built on stalks of grass and placed above the line of inundation. Livingstone argues that this must have been the result of experience, since, had the insects waited until the inundation had invaded their subterranean quarters, the required soil for fashioning their elevated nests could not have been obtained. Some of these raised rooms were the size of a bean, others

as large as a man's thumb. Could the great missionary explorer have fallen upon some species of Cremastogaster, who thus utilized their tent-building habit?

It is certain that ordinary showers do not stay, but rather quicken, the commune's activity. One often sees them followed almost immediately by a vigorous rush of workers from the gates bearing earth-pellets. Part of this dumpage may have been the inwash of dirt, but most of it was evidently new earth, which, moistened and softened, made easier digging, a fact which these opportunists at once saw and utilized.

Within the numerous galleries and rooms, all under cover and in darkness, and thronged by myriads of insects in continual movement, together with eggs, larvæ, and cocoons, there is of necessity much litter of various sorts. This is regularly removed by the workers, who may be seen carrying it forth and dumping it at points outside the walls. The interurban highways, as uncovered by the writer, were never found obstructed by rubbish or fouled by filth. As compared with the streets of many of our own cities and towns, they were models of tidiness.

The mound-making ants, while keeping at times to certain fixed trails, do not lay out permanent roads by which to communicate with surrounding fields. But with such species as do thus unite their large communities with near environments, the roads are kept in excellent condition. For example, the disk or plaza or pavement of the agricultural ants of Texas is kept during summer hard and smooth, usually denuded of grass and weeds, and well policed of extraneous matter. The several roads that radiate into the harvest-fields of ant-rice and other seeds are also kept scrupulously clean.

It has been thought that the hospitality extended by ants to beetles and other myrmecophilous insects is in part due to their value as general scavengers—just as men in a ruder stage of civilization have kept (and still keep) dogs, and as certain communities protect by law turkey-buzzards and gulls. The relations of these alien associates to the food supply have heretofore been pointed out, but their usefulness in removing communal garbage may be a factor in maintaining these strange companionships.

Perhaps one might venture to suggest that the steady, ample, and congenial occupation of ants must contribute to good health, the chief aim of sanitation. And therein may be included an evenly poised temperament, freedom from anxiety for present and future support, and absence of the strain and wear of nerves which come with troubles over property and the want thereof—all of which are characteristic of ants, and which may be counted for these and other lower orders a boon of nature.

This estate, with its sequent of perfect content and happiness, ants attain by complete absorption into the commune, the entire atrophy of the sense of personal ambition and possessions. Men seek the same in a way precisely the reverse: by the enlargement of personal importance, and the acquirement and accumulation of personal property. Could the experiment be fairly made in a human commune, it might be found that men could more readily and completely secure the repose of happy minds within wholesome bodies by the methods of the ants than by their own. In all ages men have sought this repose in organized communes, religious and secular; but these have been marked, for the most

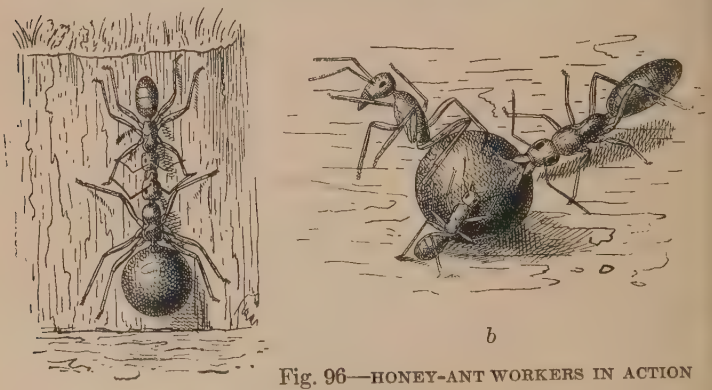
part, by the elimination of that element which is the central vital impulse in the life of an ant commune—the production and nurture of the young. When the larvæ and pupæ are removed from ants they soon degenerate and decay. Is it different in human communes? Under natural law, can it ever be so?

In the various phases of sanitation considered we observe that ants attack the problem by precisely the same method of communal labor that prevails in other departments of public service. Just as every citizen is a warrior without a board of war, and a policeman without a police department, and a worker without a board of public works, so without a board of health every citizen of these emmet republics is a sanitarian. No street commissioners are needed to purge the public highways, for every citizen feels in herself the responsibility of a street commissioner. Literally, every ant looks out for her own premises; and not only so, but for her neighbor's premises as well. In fact, there is no distinction in this regard, for every part of every street is held to be equally the charge of every ant. What a paradise of wholesome purity our city streets might be if citizens would take such an attitude, or if they would go as far as unanimously to abstain from causing litter and scattering filth! We shall never reach the ideal City of Health until the individual conscience has been educated and elevated to the duty of entire cleanliness within the dwelling and around it, and upon the public streets and parks, as personally due to community.

It is perhaps due to their overmastering patriotism that one fails to discover individual benevolence in ants. Friendships and personal affection in the limited and specialized sense familiar among domestic animals are

unknown. There are, indeed, actions that at first give the impression of such sensations, and it is not easy at times to mark the difference between the product of communal instinct and the promptings of real individual kindness. But the evidence, on the whole, seems to be against the existence of any sentiment separate from that Spirit of the Sodality which, with and under all sensori-motor reflexes, sweeps on the mass and the individual alike, with whatever variations, diversions, and seeming contradictions, to the one sovereign end—the perpetuation of the commune.

A few examples from my studies of the honey-ants will illustrate this view. It was seen in exploring the nests in natural sites that the workers showed great interest in the preservation of the rotunds, or honey-bearers. As the honey-rooms were opened, and the rotunds disturbed from their roosts, the workers of all castes rushed eagerly to them and dragged them into the unbroken interior (Fig. 96). Sometimes several would join



a *b*

Fig. 96—HONEY-ANT WORKERS IN ACTION

a—Honey-ant dragging a rotund up a wall. *b*—Workers moving a rotund, or honey-bearer

in removing one rotund, pushing and pulling her along. A sketch was fortunately caught of a worker-major dragging a honey-bearer up the perpendicular face of a cutting made while excavating a nest. The mandibles of the two insects were interlocked, and the worker backed up the steep, successfully drawing her protégée. This interest in these unwieldy rotunds is maintained in the daily life of the formicary. They are regarded as dependents, like the queen, the virgin females, and males, and are fed and tended as such. Here is at least the semblance of beneficence, but it is doubtful if such action passes beyond the control of communal instinct; for, on the other hand, a number of examples fell under notice which caused doubt as to the existence of a personal sentiment toward special cases of need, outside the routine limits of communal service. I observed several of these.

After the soil was duly prepared in my artificial nests, the ants were introduced and left to work out their own habitations. The honey-bearers were thus mingled upon the surface with the workers, upon whom fell the entire task of home-making. The latter at once began digging galleries and rooms.. In bringing up and distributing the pellets, there was much opportunity to show carefulness and tenderness toward the honey-bearers scattered over the surface. No such action was noted, although I was anxious to discover such excellences in my little charges. On the contrary, there were exhibitions of what seemed cruel neglect and even positive cruelty. For example, the grains of soil, instead of being dumped on unoccupied spots, were heaped around the rotunds until the poor creatures were literally buried alive. It would have been easy for the carriers to draw

their fellows aside or to go around them; but this did not occur to them, or the disposition to such service was wanting.

Again, as the galleries were made and honey-rooms gradually took shape, most of the rotunds managed to roll into them and secure a place therein. They painfully attained their perches unaided by the workers. Some of them on their route got fastened in the gangway in most uncomfortable positions, with heads downward and bodies variously awry. The workers passed by and over them continuously for many days without the least apparent concern, and without one observed effort to relieve their comrades, who could have been righted readily and drawn into the chambers.

Once more, the rotunds often dropped or were shaken from their perch against the roof to the floor. They remained just as they fell, except when they were able to clasp some near-by clod, or bit of gravel, or surface of a wall. In such case they recovered their perch or put themselves in a comparatively comfortable position. The greater number, however, lit upon the round abdomen in such wise that the body was erect and the legs were thrust out unsupported. These unfortunates were faithfully attended, often cleansed and caressed, after the prevalent hereditary manner toward dependents, but in no single instance did the workers attempt to right them and restore them to the roof. Yet they were well able to do so, and the fallen rotunds were in sore need of help. Some of them lived more than two months in this awkward position (Fig. 97).

But evidently they were most uncomfortable, for the few who were within my reach eagerly accepted aid. The offered stick or quill was clasped so firmly by the

mandibles, sometimes aided by the feet, as to enable me to transfer the bulky creatures to any point near by, and even to lift them out of the nest. Here, again, the idea, or at least the act, of helpfulness was lacking. If

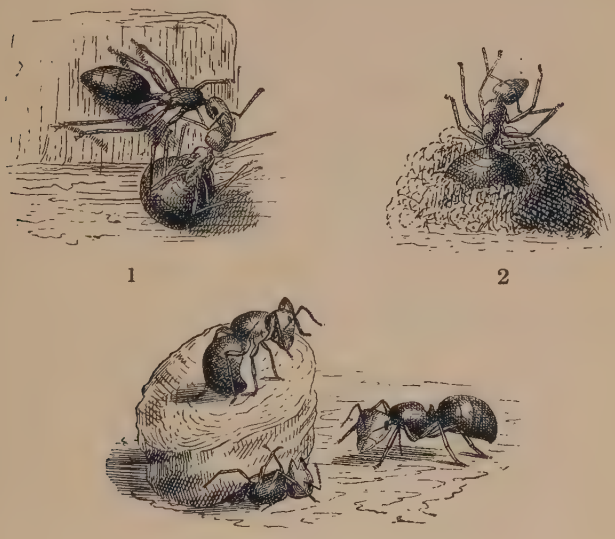


Fig. 97—HONEY-ANTS AND ROTUNDS

1. Worker honey-ant feeding a rotund. 2. A rotund honey-ant partly buried by mining workers. 3. A rotund in trouble—a "priest" and a Levite near by.

we suppose the power to communicate their distress and desires to have been possessed by the honey-bearers, we must think the workers even yet more lacking in feeling and intelligence. In any case the power of benevolent initiative seemed wholly wanting.

One more case. A honey-bearer was partly buried under her perch, that portion of the roof having fallen. Her abdomen was quite covered by the sandy particles

at the margin of the little landslide. A rescue would have been easy, but it was not undertaken. A sketch made shortly after the accident shows a worker-minor standing before the rotund with head and body erect, antennæ attent, with every mark of curious interest in her pose. She watched the struggles, and (as it seemed to me) the mute appeals of her unhappy fellow, who by great exertion had heaved up the clod somewhat, and then "passed by on the other side." Meanwhile a second worker was perched atop of the clod, coolly and cozily combing her back hair and antennæ! This tableau fitly characterizes the workers' behavior in such cases.

Such facts, which might be multiplied, incline one to the view that personal benevolence, as distinguished from tribal or communal benevolence, does not exist in ants. I cannot even assent to Lord Avebury's suggestion [Lb. 2, p. 497] that there are "individual differences" among them, and that, as with men, there are priests and Levites as well as good Samaritans. The apparent cases of beneficence, outside the instinctive actions that lie within the line of formicary routine, are so rare and so doubtful as to their cause that, however loath, I must decide against the existence in honey-ants of even so much personal benevolence as would make an emmetonian "good Samaritan."

It is true that many of the above observations were made upon insects living in artificial conditions, but they cannot be far away from their habits in a natural site. Moreover, it is possible, not to say probable, that there may be species that show greater aptitude for acts of personal kindness, just as some have special aptitude for war, while others are deficient in courage. But all the facts within the author's knowledge confirm the above

conclusion. The beautiful acts of unselfish devotion to dependents, especially the helpless young, the self-denial, the vicarious self-sacrifice, the utter elimination of self so often seen—all these spring solely from the relations of ants to the commune. They are the acts of the ant-citizen, in whom all the functions of life are centred and absorbed, not of the ant-individual, an independent living unit.

Patriotism, communal loyalty, communism, or by whatever name we may designate a sentiment or impulse for which, in the poverty of our speech and the limits of our sympathies with a sphere of life so far outside of our own, we have no exact word, is the one passion that moves the typical ant in its varied acts. Personal sentiment there is next to none. Outside the routine of communal duty and service, the actors in an ant commune know no law but the instinct to serve and preserve the commonwealth. Even in satisfying the demands of appetite the individual is lost (with the workers, at least) in the public interests, for even the contents of one's crop are held at the service of the community.

Of course, there is reason for this condition. An imperious law of co-operation in the mass does not favor the development of strong individual characteristics. The mechanical order that assures the sodality and safety of society among insects would be disturbed by strong personal ties, which would thus introduce a divisive and enfeebling force, especially in times of communal peril when all sentiment and service should be concentrated upon public interests.

CHAPTER XVI

A NOTE IN REVIEW

WHILE emphasizing, to the utmost that known facts can justify, the marks of superior instincts in ants, and while believing that their social organization has developed powers and incited to behavior that suggest human conduct in certain communal conditions, the author must not be understood as in any degree confounding emmet instinct with human intellect. There is an impassable gulf between them.

To reflect upon a rule of conduct; to decide thereupon and frame one's behavior accordingly; to assemble facts gleaned from the past and from the present; to reason upon and deduce therefrom principles of duty and service, of social and individual government, of personal responsibility and worship—and immortality—all this, which is impossible to the ant, but is within the ordinary powers of man, set him in a class by himself, so far apart from all other animals that, in contrasting or comparing the one with the other, and in tracing resemblances between their physical and social actions, we shall fall into serious error if we forget this fundamental difference.

When, therefore, we use the word "intelligent" to express a quality of animal behavior, as it seems necessary to do in the deficiency of our language, we shall escape confusion in our philosophy if we remember that "intelligent" and "intelligence" as so applied are terms of

convenience and not of accuracy. Under such limitations, a review of these pages compels the conclusion that among all the lower animals ants must be ranked for intelligence as most nearly resembling man in the quality, variety, and complexity of their achievements. Can we suggest any natural cause for this?

The development of civilization has come largely through the interaction of life upon life. And this has had its chief effect in cities and towns, where human beings more closely and continuously affect one another. A trace of that fact remains in the current use among us of the word "pagan." Christian civilization had its first and widest acceptance among the cities, while the rural sections held to the old religious forms. Hence the Roman name for countryman, rustic (*paganus*), came to be the equivalent of non-Christian or heathen.

It is doubtless due to the same underlying fact or force in nature that ants have acquired traits that place them among the most intelligent members of the insect world. The vigorous reflex of life and habits which existence in a commune compels, widens the horizon of activities and develops and nurtures facilities and conduct that strongly mark the possessors as superior. To ants as well as to men, the commune is a school. It would seem to result that the more general the participation in communal activities, the higher and more widely distributed will be the advancement.

The idea—fancy or fact, as one may choose—that the communes of ants and other hymenopterous insects are organized after the fashion of human government is not a novelty. Long ago, Shakespeare, whose high endowments of intellect and sympathies brought him with almost unerring course to the very arcanum of nature's

mysteries, conceived of the bee commune as a well-ordered kingdom, whose "divers functions" are bound together by "obedience." The passage is well worth quoting for its bearing upon the matter before us:

> "So work the honey-bees,
> Creatures that, by a rule in nature, teach
> That act of order to a peopled kingdom.
> They have a king and officers of sorts;
> Where some, like magistrates, correct at home;
> Others, like merchants, venture trade abroad;
> Others, like soldiers, armed in their stings,
> Make boot upon the summer's velvet buds;
> Which pillage, they, with merry march, bring home
> To the tent-royal of their emperor,
> Who, busied in his majesty, surveys
> The singing masons building roofs of gold;
> The civil citizens kneading up the honey;
> The poor mechanic porters crowding in
> Their heavy burdens at his narrow gate;
> The sad-ey'd justice, with his surly hum,
> Delivering o'er to executors pale
> The lazy, yawning drone. I this infer,
> That many things, having full reference
> To one consent, may work contrariously."
>
> —*King Henry V.*, Act I., Sc. 2, l. 187 sqq.

Making due allowance for poetic license, and taken in its broad intent and general sense, this passage expresses fairly well the varied duties under one common discipline that occupy the energies of an ant commune. The reader can analyze it and follow out the analogies for himself. Perhaps he may be able to point the needle of his thoughts to that "rule in nature" which brings about and regulates this "act of order." If so the author will confess that he has compassed a mystery that thus far has eluded his own research.

But for the "act" itself we may venture, without

justifying the charge of anthropomorphism, to borrow a word from human civics. Plato distinguished four kinds of character-making "enthusiasm" among men —prophecy, prayer, poetry, and love. These give to human faculties the stimuli which urge man to achieve his highest destiny. We might enlarge the list by at least the element of patriotism, and thus mark another likeness between man and social insects. For patriotism —that is, a supreme devotion to the commonwealth— is the prevailing "enthusiasm" among ants, bees, and wasps. With them one finds no discount laid upon the communal workers and military guards. All, except needful dependents, are laborers and warriors. All are alike devoted to the civil welfare and defence.

Many times and in many ways the devotion of ants to their commune has been tested. The rule is well-nigh invariable of instant and absolute self-abnegation, and surrender of personal ease and appetite, life and limb, to the public welfare. The posting of sentinels at gateways is customary, and they are apt to know first the approach of danger. With heads and quivering antennæ protruded from the opening, these city watchmen not only dispatch within all news of threatening peril, but rush out with utter abandon to face the foe. With ants patriotism is not "second nature"; it is instinctive, inborn, seemingly as strong in the callow antling as in the veteran brave. It has no second place. It is first, always!

It must be confessed, however, that it is rigidly exclusive. Racial catholicity is not an emmetorian virtue. Ants are without that elastic hospitality which embraces and assimilates all species of their family. Even the slave-makers hold their domestic auxiliaries strictly

distinct in the radical function of propagating and thus perpetuating the species.

If one should seek some directing or governing personal power of that system by which the complex and varied results which these studies note are wrought out with almost unbroken unison among hundreds of thousands, even millions, of individuals, he would find his research thwarted at every point. There is a smack of royal authority in the title "queen" given the ant in whom is concentrated the function of maternity for renewing the life of the whole community. But in this sense the word is figurative, for queenhood means simply motherhood. Beyond the brief initial period of a formicary, when the solitary female in her circular cell has unlimited power over her scant domain, and in her single person represents the norm of all reproductive, nutritive, constructive and administrative forces, an ant queen has not a shadow of that function of rulership which the words "queen" and "king" express in human relations.

From the moment that she has raised around her a band of workers strong enough to take up the labors of the growing society, she becomes merely an immense vital organ for producing eggs. She does not even care for these, as she did with the first few laid; for they are whisked away by attendant workers the instant they leave her body, and thenceforth are the common charge of the colony. A girdling corps of courtiers attends her day and night, whose members care for her personal wants, restrain her movements within safe limits, and collect and distribute to the nurses the precious atoms of life upon which her importance depends. But no breathing of rulership or authority or governing influence of any sort issues directly from her.

Where, then, is the headship of the State? Is it vested in the courtiers nearest the queen's person? Are they a sort of cabinet or board of governors, among whom the several functions of governing are distributed? All observations show that their chief office is to secure to the community the eggs upon which its future existence depends.

Is government lodged with the sentinels, who seem to represent the fighting or defensive elements of society? There is no war-lord. There is no commander-in-chief. There is no standing army and no soldier class in the large majority of species, although in "necessity's sharp pinch" every citizen becomes a soldier. Certainly our mound-making ants, at least, are not a military government, though every guardian of the gates is at once and equally the embodiment of military authority, and bears in its own person every grade from general to private.

Perhaps the nurses, who include in their nursery service the duties of hospital corps and medical staff, are the fountains of governing power? No! Among men it may be true that "the hand that rocks the cradle rules the world"; but nursing ants in their offices keep themselves to their own sphere, and cannot be said even figuratively to sway the policies of the ant-hill.

Shall we, then, fall back upon the great body of builders and foragers and laborers generally? Are they organized into "unions," with chapels, delegates, brotherhoods, chiefs, boards, circles, and assemblies, who have gradually developed an influence that controls the commonwealth? On the contrary, perhaps the most perfect-known example of absolute "individualism" among so-

cial creatures is a typical ant society. Therein every ant is, as nearly as is conceivable, a law unto itself. Here is neither congress nor legislator. Every individual seems to follow the desires and devices of her own heart. But here also is such perfect obedience to "law" as only insect commonwealths show among all known organized societies. Where is the source and where the potent centre and motor of this law?

The mystery deepens as one's inquiry widens. Here is effective government; but where are the governors? "Those that think"—sang Goldsmith—"must govern those that toil." Here are toilers enow; but of that higher, or supposed higher, class who think out the problems of State and the means for their solution the most careful searching finds no trace. The varied and complicated facts of governments, as men know them, here meet the observing naturalist and the speculating philosopher. But neither naturalist nor philosopher has yet put his probe upon the secret source of government among ants and other social insects.

Can there be government without visible governors? Here in our ant city one sees home-making, home-guarding, home-nurturing; the building of roads, store-rooms, nurseries, vast structures that relatively rival those of the great centres of human population. Here one sees the gathering of supplies; the storing of crops; the waging of war; the utilizing of captives from alien tribes for co-operative service; the keeping of domestic herds; the policing and sanitation of habitations and streets; the nurture and care of the young. All the practical results of organized society one sees in the emmet State. Is not this government?

> "For government, though high and low and lower,
> Put into parts doth keep in one consent,
> Congreeing in a full and natural close
> Like music."

But where is the master musician and his orchestral leaders? Whose hands arrange the parts, direct the performers, give unity to the whole, and from their wondrous "congreeing" of action bring forth this perfect piece of social harmony? The Spirit of the Commune!—do you say? It is a phrase to drape our ignorance. The reasonable answer still evades the student's grasp. Though the natural philosopher may justly claim that "in nature's infinite book of secrecy a little I can read," here is a page for whose interpretation no Daniel yet has come. Beyond the veil of recorded science an insoluble, at least an unsolved, mystery lies.

This we perceive: Every ant is a law unto itself; and in every individual the self-directing faculty is well-nigh perfect. There is no private property. All citizens are equals—absolutely equals in ownership of the communal property and in the use of, the authority over, and the service and responsibility for the same. All serve, save natural dependents; but all apparently are free to choose the quality, the period, and the amount of service. There is no visible head, no representative class or body within which the control of the commonwealth is embodied; and yet, by some occult force hitherto unknown to men, all the beneficent effects of government are wrought out with the regularity and precision of an automatic machine. It is true to-day, as when Solomon announced it many centuries ago, that this work goes on without "guide, overseer, or ruler."

Here, in this strange commune, with its absolute law

and impersonal but imperial executive, the self-directing power of every individual seems perfect. Is this socialism?—nature's type of a practical socialism? Learn this, then: if socialism as a form of human government would be equally or even approximately successful, *it must first attain that perfect individual discipline and absolute self-control, self-abnegation, self-surrender, and self-devotion to the good of the whole community that one sees in a Commonwealth of Ants.*

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FOR the sake of economy in space, and to save breaking up the pages with foot-notes, the authors and works referred to in the text of this book are designated thus: Every author, as a rule, has been given as a symbol the first or the first two letters of his name. His several works used, the titles of which are printed in full in this table, are indicated by a number or by successive numerals. For example, [McC. 7, p. 243] shows that the text refers to the seventh title (*Nature's Craftsmen*) listed under the name McCook.

Due acknowledgment has thus been made throughout the text of those to whose writings the author has been largely indebted. Yet, among these fellow-naturalists, he here expresses his special indebtedness to the veteran myrmecologist Prof. August Forel, M.D., of Zurich, who inspired and guided his earliest studies; and to Prof. William Morton Wheeler, of Harvard University, who stands *primus inter pares* among the later and younger myrmecologists, by whose devoted and intelligent labors the writer and readers of *Ant Communities* have profited.

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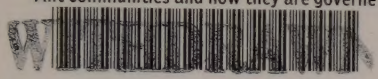

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